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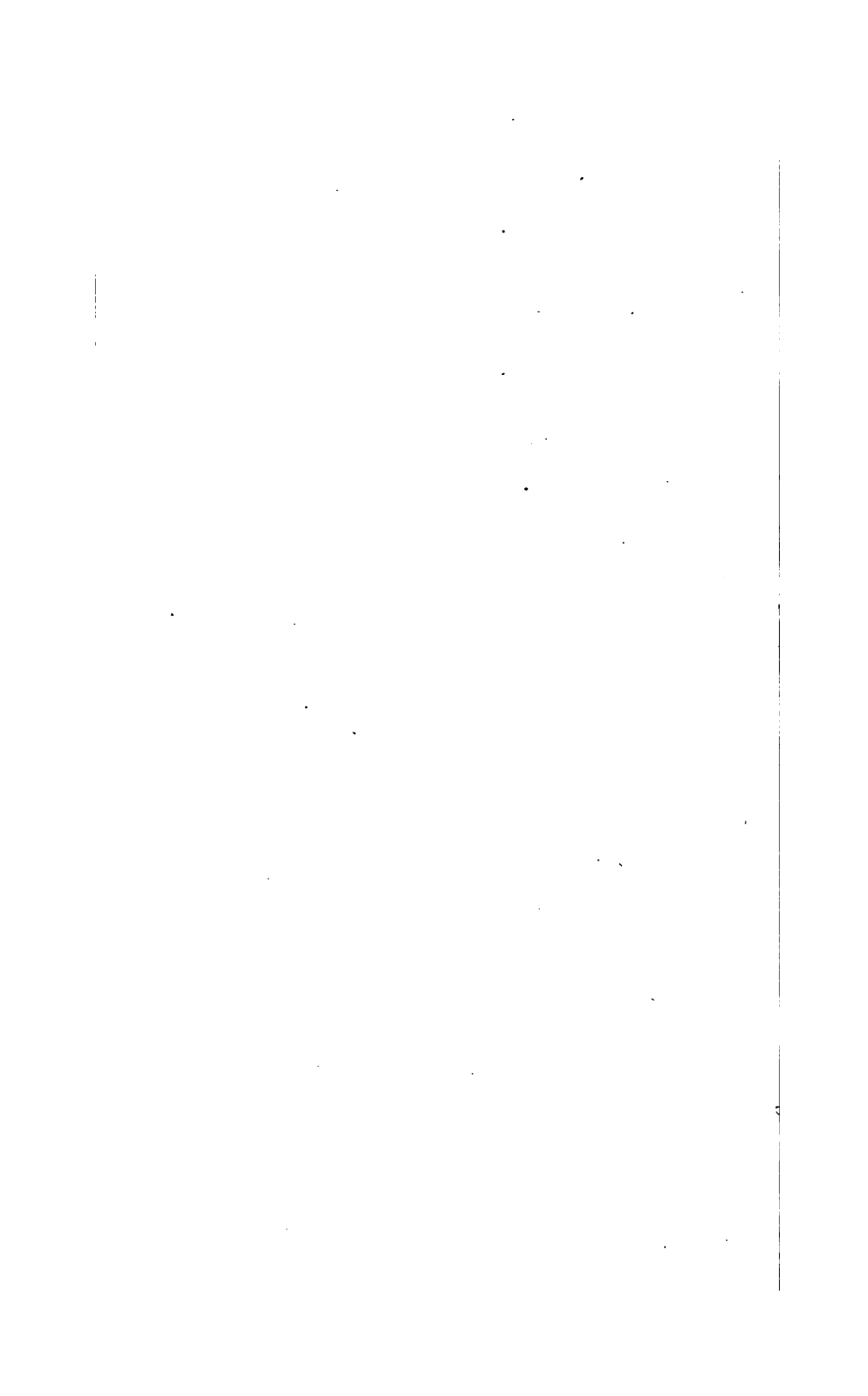
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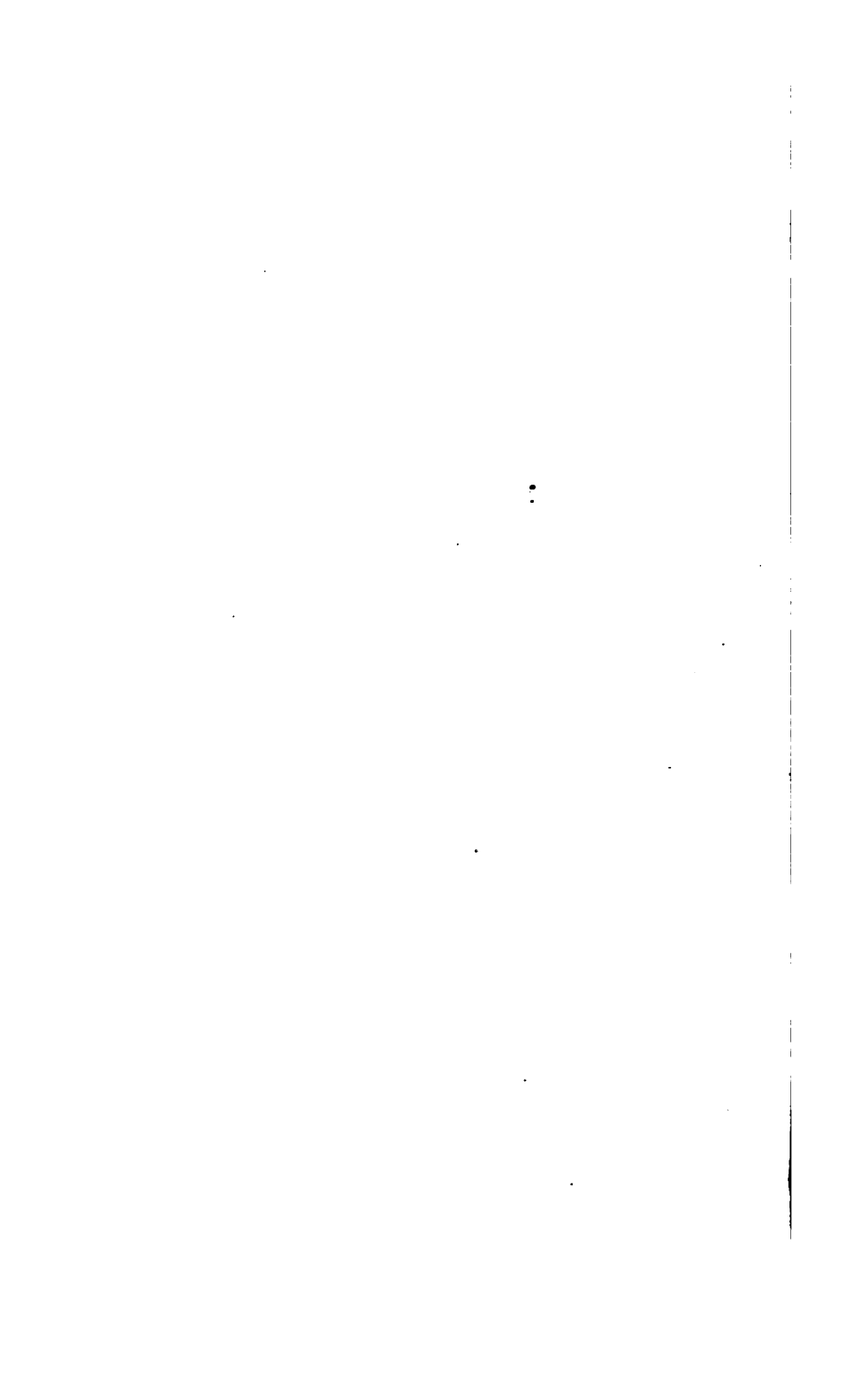


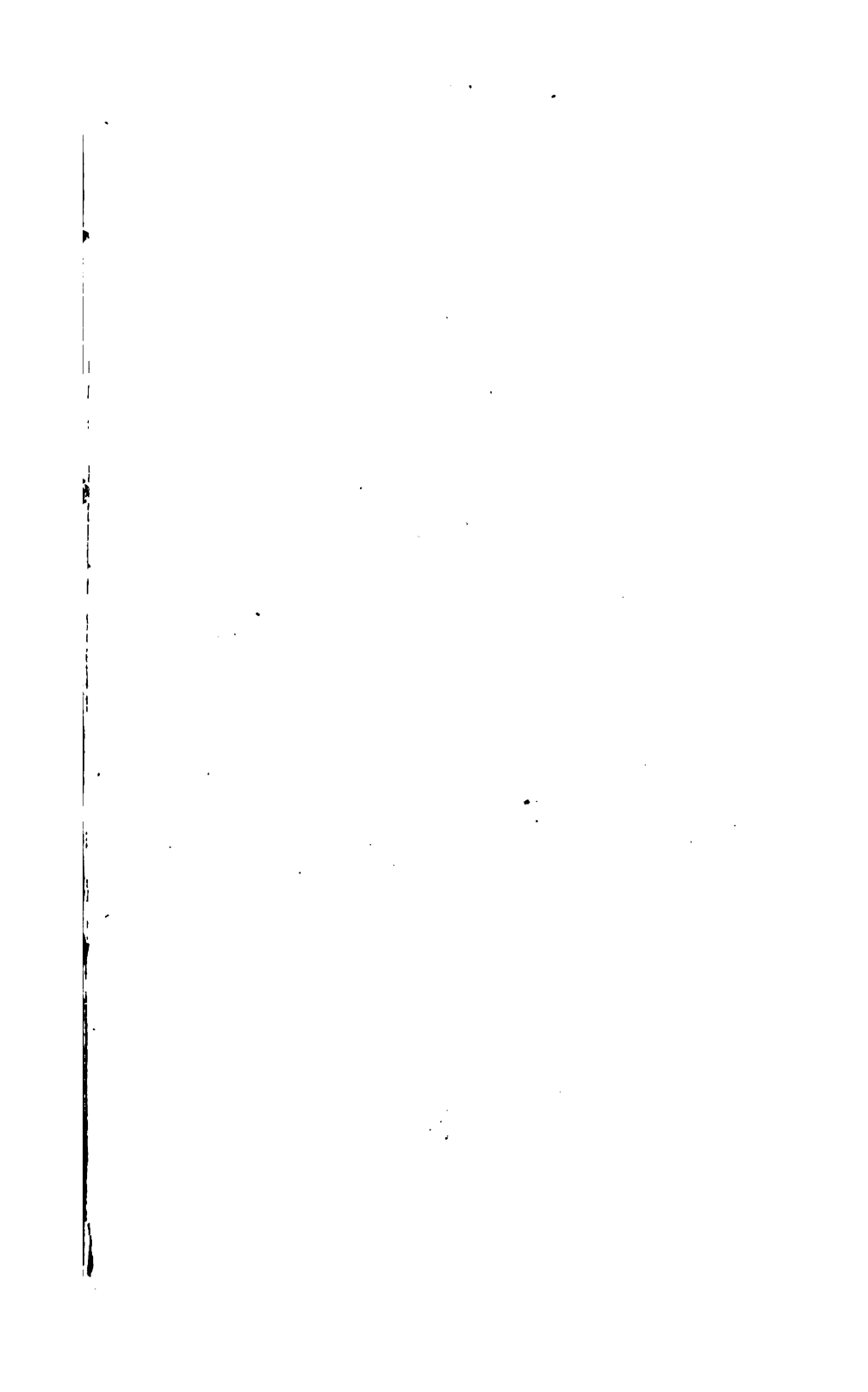




THE

EXCISE OFFICER'S MANUAL.







Joseph Bateman.

From a Painting by Clemente Padellaro.

LONDON:
WILLIAM MAXWELL, BELL YARD, LINCOLN'S I
LAW AND GENERAL PUBLISHER.
1852.

L. Eng. Assoc.

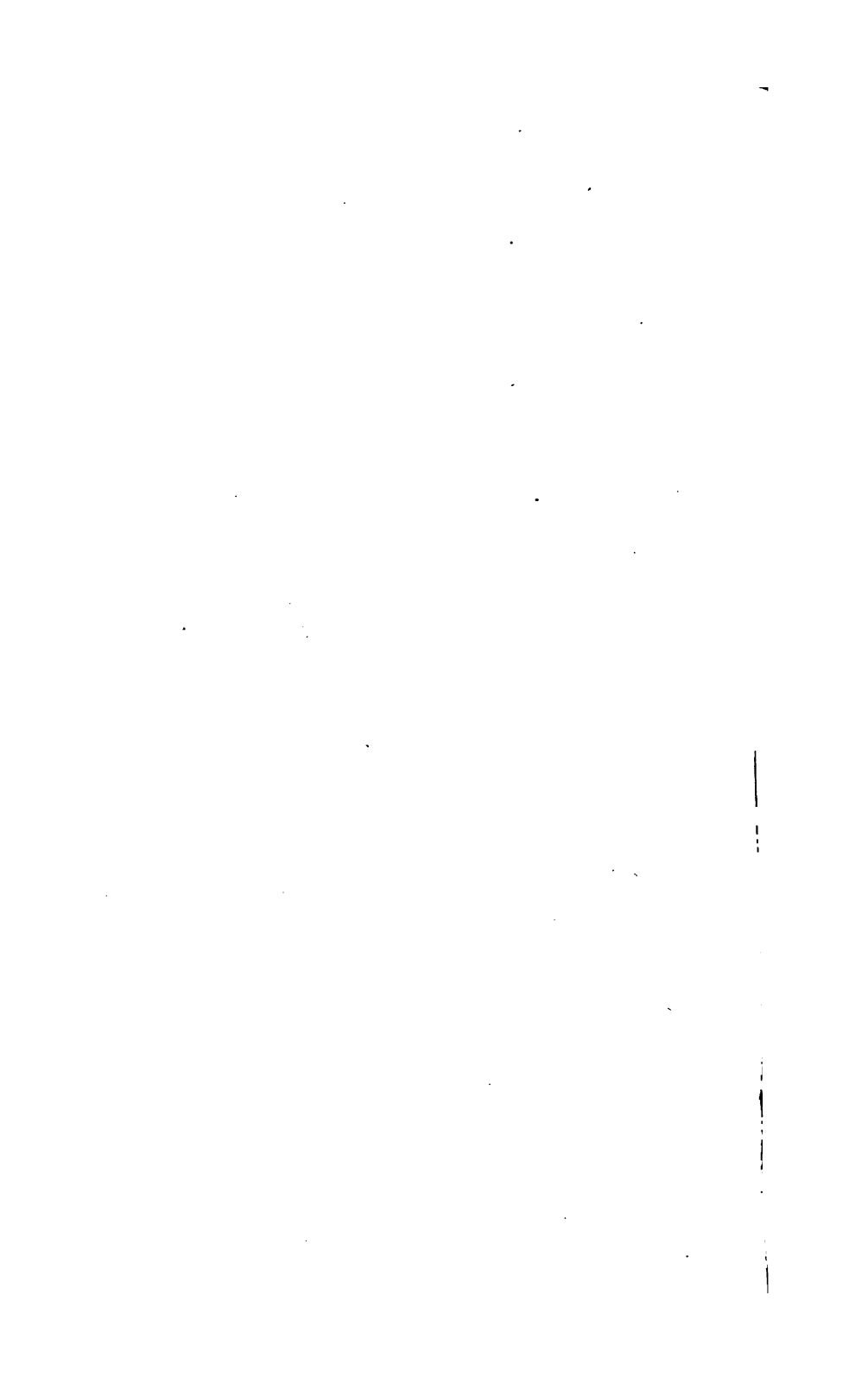
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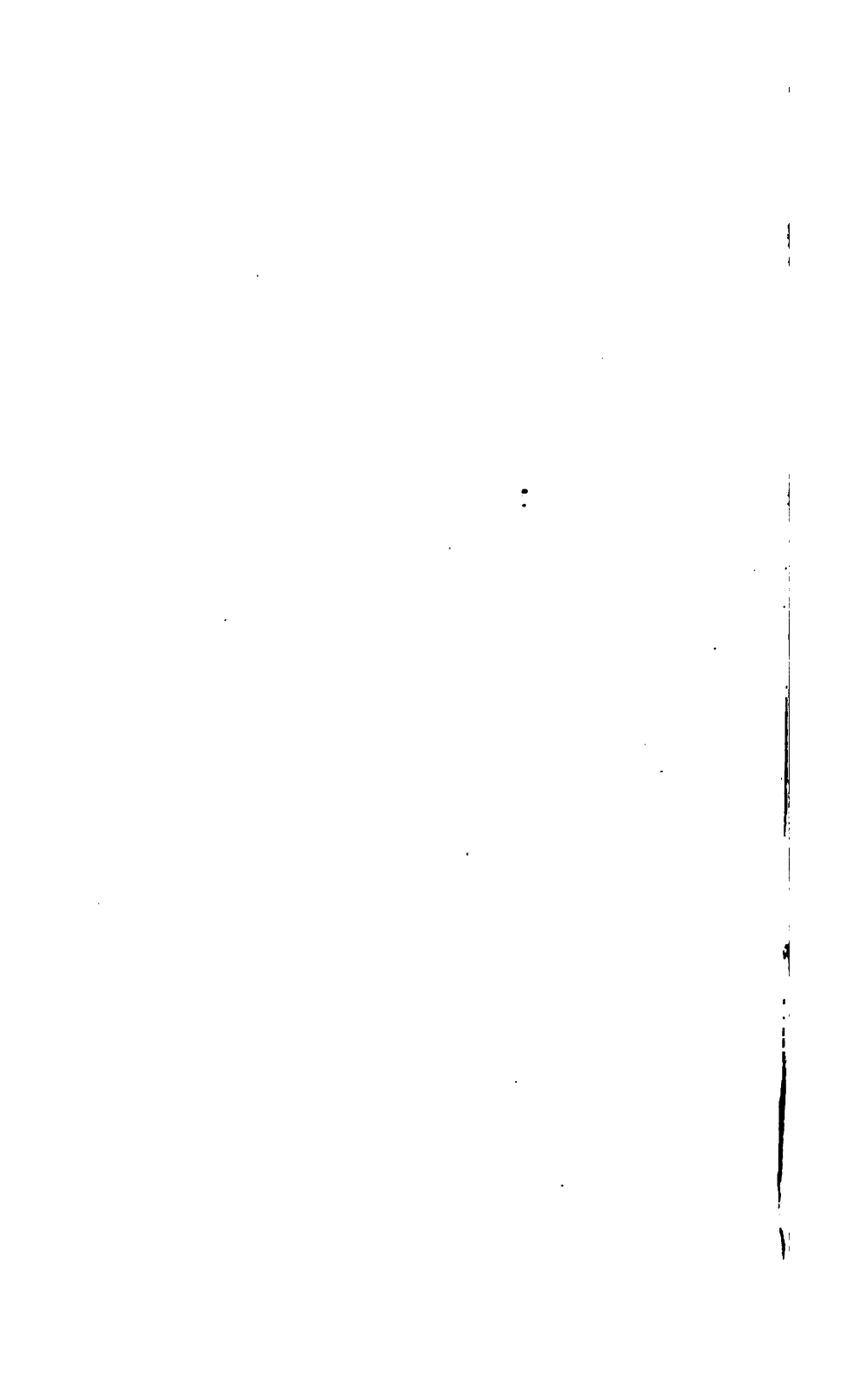
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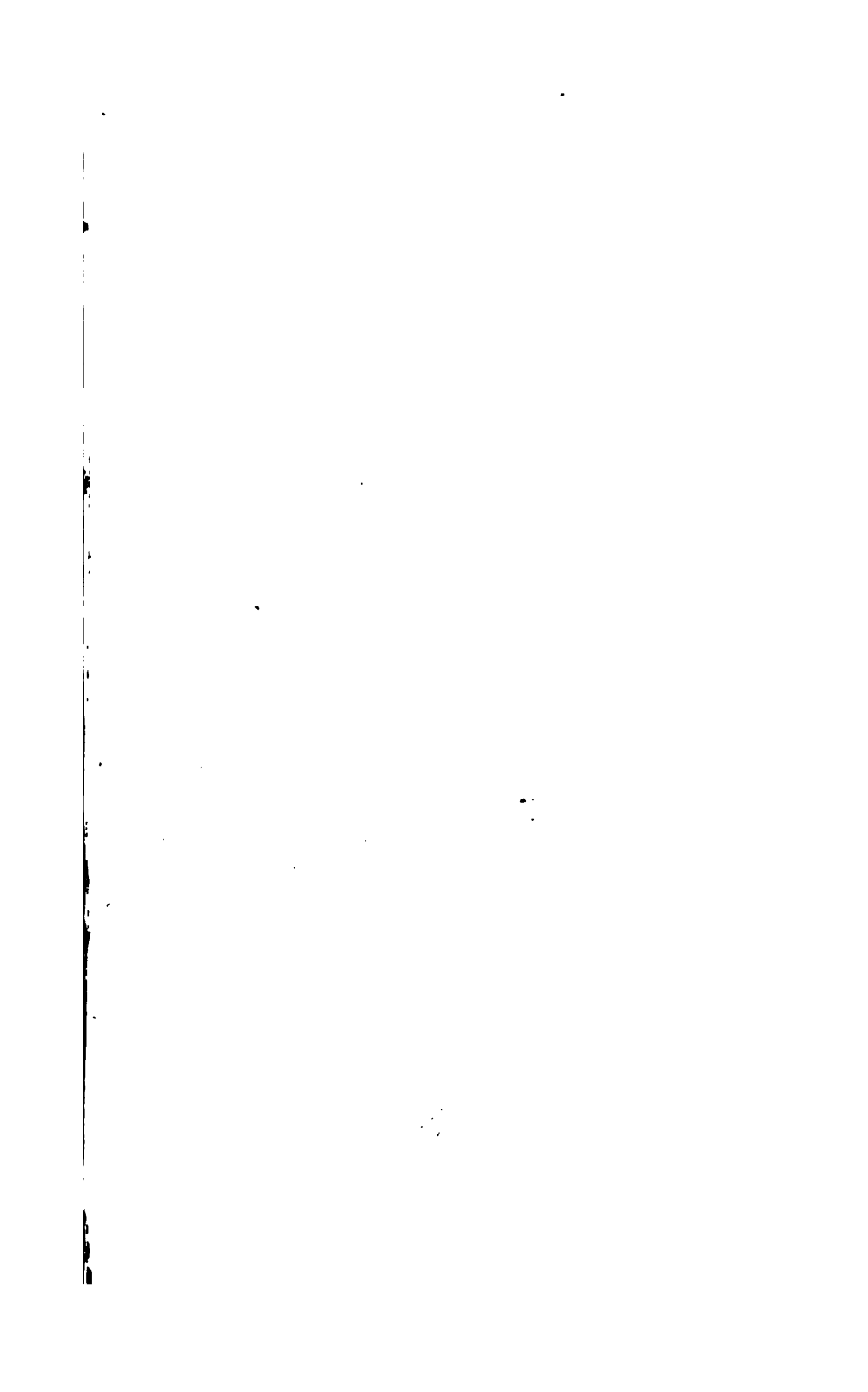
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THE
EXCISE OFFICER'S MANUAL.







Joseph Bateman.

From a. Painting by. C. Mason. Parsons.

THE HISTORY OF THE

REIGN OF

CHARLES THE FIRST

BY

JOHN RICHARDSON

ESQ.

OF THE

LONDON:

WILLIAM MAXWELL, BELL YARD, LINCOLN'S INN,
LAW AND GENERAL PUBLISHER.

1852.



Joseph Bateman.

From a Painting by Clement Perkins.

THE
EXCISE OFFICER'S MANUAL:

BEING
A PRACTICAL INTRODUCTION
TO THE BUSINESS OF
CHARGING AND COLLECTING THE DUTIES
UNDER THE MANAGEMENT OF
HER MAJESTY'S COMMISSIONERS OF INLAND REVENUE.

BY
JOSEPH BATEMAN, LL.D.

SECOND EDITION.

WITH A NEW ARRANGEMENT AND CONSIDERABLE ADDITIONS
AND IMPROVEMENTS.

LONDON:
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1852.

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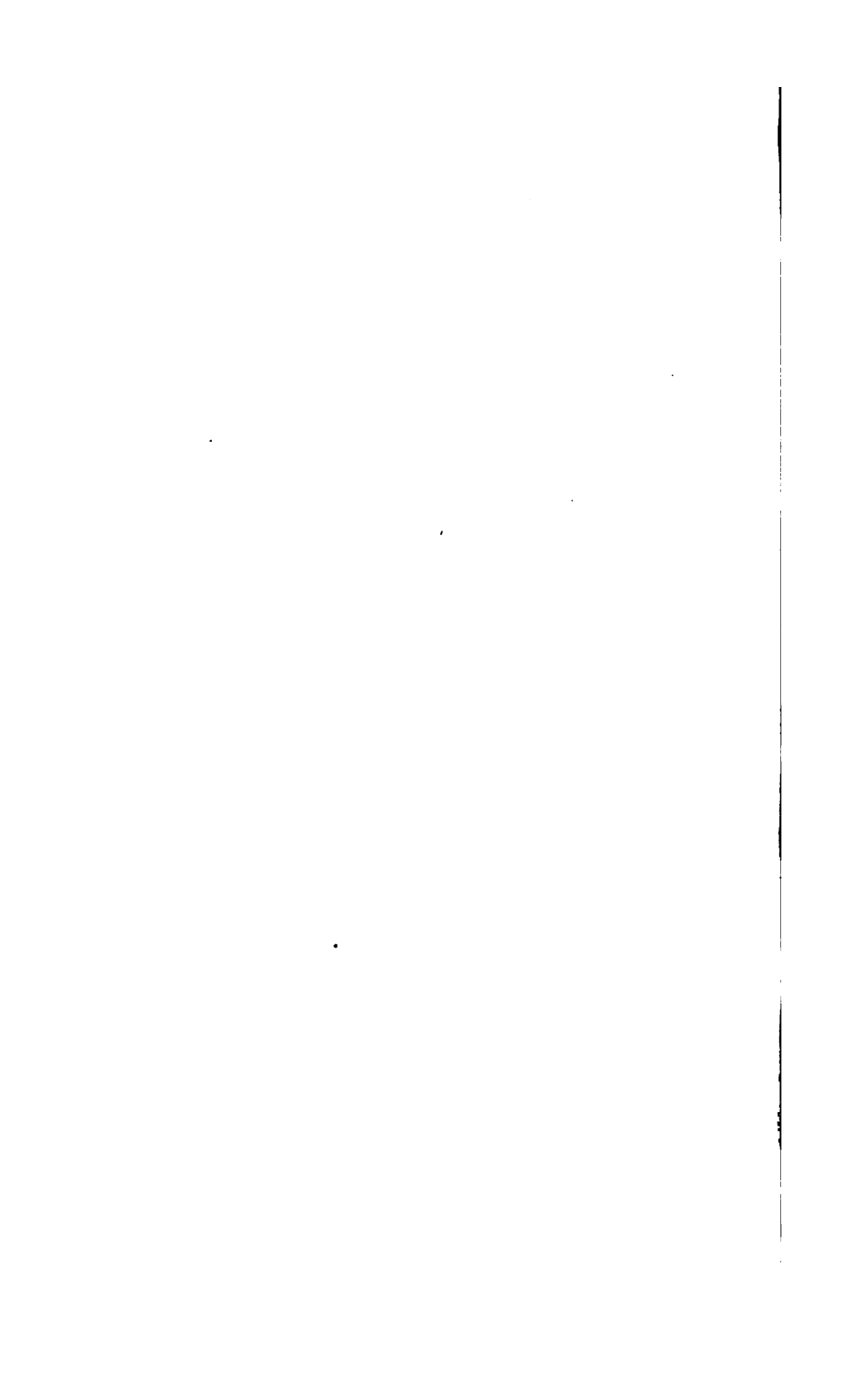
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THE

EXCISE OFFICER'S MANUAL.

INTRODUCTION.

THE EXCISE * (from the Belg. *accise*, tributum, or from the Latin, *excisum*, to cut off, as a part of the profit cut from the whole), is an imposition upon home-made goods and commodities as distinguished from *Customs*, which is a

* The Excise has also been defined to be a tax laid, in the first instance, upon the manufacturer or vendor of various commodities, though ultimately, in the increased price, falling upon the consumer. (*See Jacob's Law Dict., Gilbert's Exch., Chit. Burn's J.* 273.) The origin of this great revenue, with the view to any regular systematic establishment of it, may be traced to the Republican (or Long) Parliament, in the reign of Charles I. (*Higm. Excise.*) An attempt had indeed been made to introduce the Excise in 1626, by a Commission under the Great Seal; but Parliament having remonstrated against the measure, the Commission was cancelled. (*Rep. Comm. Ing.*) The Parliamentary Ordinance for its establishment was dated 16th May, 1643; the articles upon which it was then imposed being beer, cider, wine, and tobacco. Soon afterwards the Parliament extended the impost to flesh, sugar, and such a multitude of other commodities, that it might fairly be denominated general. It was established by Mr. Pymme, whom Sir William Blackstone justly styles the father of the Excise, as the chief mode of taxation; and it was continued during the whole of the Commonwealth. (*Scobell. 1 B. Comm.* §19, *High. Ex.*) Upon the restoration of King Charles II., the Excise was continued, and some part of it given to the Crown by way of purchase for the feudal tenures and other oppressive parts of the hereditary revenue. This was effected by two Acts, 12 Car. 2, cc. 23 and 24, which are still usually considered as the foundation of the English Excise Laws. Cap. 23 is entitled "A grant of certain impositions upon beer, ale, and other liquors, for the increase of his Majesty's revenue during his life." Cap. 24 is named "An Act for taking away the Court of Wards, and Liveries, and Tenures in capite, and by Knights' Service and Purveyance, and for settling a revenue upon his Majesty in lieu thereof." Duties were imposed by these Acts upon beer, cider, perry, metheglin, or mead, vinegar-beer, and aqua vitæ, made

duty on goods imported from another country. Excise duties are at present imposed on spirits, malt, soap, paper, hops, sugar, post-horses, stage-coaches, railways, and licenses for exercising various trades.

For managing this important source of Revenue (together with the duties on Stamps and Taxes, which have recently been consolidated with it,) there is a Board of seven Royal Commissioners (now called the Commissioners of "INLAND REVENUE"), who sit and act daily at the chief office in Old Broad Street, in the city of London, and Somerset House, in the city of Westminster. These commissioners (of whom three, and for many purposes, two, form a quorum,) are intrusted (subject to the control of the Treasury), with

and sold; and on beer, cider, spirits, and strong water, imported; and on coffee, chocolate, sherbet, and tea, made and sold. Various articles which have at different times been chargeable with Excise duties, have subsequently been relieved from the burden, or transferred to other departments. In 1797 the following articles were subject to Excise duties, viz.:—Auctions, bricks, glass, hops, licences, malt, paper, soap, spirits (British), vinegar, starch, stone bottles, sweets and mead, tea, tiles, beer, candles, coaches, cocoa-nuts and coffee, cider and perry, hides and skins, pepper, printed goods, salt, spirits (foreign), tobacco and snuff, wine, wire. In 1833, the duty on the thirteen incidents last mentioned, had been either taken off or transferred to other departments. Others have been removed subsequently, and there now only remain under the Excise survey, hops, licences, malt, paper, soap, and spirits (British), together with post-horses, stage and hackney carriages, and railways, in England, and game certificates in Ireland, which have recently been transferred from the Board of Stamps; and sugar, upon which an Excise duty has been lately imposed. The gross receipts for the Excise duties in the years 1847, 1848, 1849, and 1850, were as follows:—

—	1847.	1848.	1849.	1850.
Spirits	5,247,498	5,476,204	5,793,881	5,944,182
Malt	4,674,116	5,443,521	5,185,223	5,645,490
Soap	1,114,959	1,210,400	1,244,397	1,309,740
Paper	810,944	789,035	859,575	915,121
Hops	444,396	395,513	208,341	309,444
Sugar	169			
Post-horse duty	161,119	146,012	144,194	142,038
Ditto Licenses	6,833	6,598	6,801	7,983
Railways	61,948	232,270	235,475	251,215
Stage Carriages	83,224	196,904	188,849	195,674
Hackney ditto	21,643	70,409	73,234	79,208
Licenses, general	1,092,501	1,104,184	1,108,545	1,130,864
Game Certificates	8,231	11,167	9,062	9,670
Bricks	690,669	462,451	462,765	27,883
Total	14,418,250	15,544,663	15,520,342	15,968,512

the management of the duties, and the appointment, promotion, and removal of the officers of the establishment : and they are assisted by a Secretary, an Accomptant-general, a Receiver-general, and a Solicitor ; each of whom has a staff of assistants and clerks attached to his particular department.*

For the purpose of charging, assessing, and collecting the Excise duties, the whole of the United Kingdom is laid out in sections, in which officers of various ranks are stationed. The largest sections are called *Collections*, of which there are in England and Wales, sixty-one ; in Scotland, thirteen (exclusive of a few districts not included in any particular collection) ; and in Ireland, sixteen. Each collection is divided into from three to seven *Districts*, making in the whole about four hundred and thirty-six. And each district is again subdivided into *Rides*, and Footwalks or *Divisions*, of which there are from three to eight in a district. The chief officer of each collection is the *Collector*, who has a clerk, and in some places, two or three. Each district is in the charge of a *Supervisor* ; and over each division or ride is a *Surveying Officer*. There is likewise a *Supernumerary Officer* in each collection in England and Ireland, and in many collections there are *Assistants* and *Expectants*.†

The distinctive character of the surveying branch of the Excise establishment is, that all its superior officers are selected from the lower ranks ; so that the appointment of new officers is invariably to the lowest grade in the service ; and the greatest part of the nominations are now made by the Lords of the Treasury.

The first appointment of a person intended for the surveying branch of the Excise is called an "*order for instructions*." The age at which a person is admissible is from nineteen to twenty-five. It is required "that he be unmarried and without family, healthy and active, without any bodily

* For the names of the present commissioners and principal officers, see the Appendix.

† See the abridged schemes of the Surveying Department in the Appendix.

infirmity, and not incumbered with debts ; that he possess a good knowledge of vulgar and decimal fractions, and a competent knowledge of book-keeping by double entry ; and be able to write correctly from dictation." When a person has obtained a nomination, he is examined by the surveying general examiners, if he reside in or near London, or by the supervisor of the district, if he live in the country, as to his knowledge of vulgar and decimal arithmetic ; * and should this be satisfactory, he is subjected to a more formal examination by a committee consisting, in London, of two surveying general examiners, a head accomptant, and a secretary or correspondent ; and in the country, of the collector, a supervisor, and a collector's clerk. Should the committee report favourably, the candidate is placed by the Board's order, for instructions under an approved surveying officer, where he remains for six weeks, or longer if necessary, to enable the supervisor to certify " that he is fitted to survey the different traders under the excise, and able to cast up both excise and malt gauges by the pen and sliding rule ; that he has gauged and stocked for six weeks in the district in which he was instructed, and entered the same in a book provided by him for that purpose ; and that he has made true vouchers, and an abstract therefrom ; and that he is in all respects qualified for a gauger's employment." After the supervisor has certified, the candidate is subjected to another examination, either by the committee or the proper collector, and if his qualifications are approved of, he is appointed an expectant, and receives a commission.†

* No person ought to be put forward as a candidate in the Excise department of the Inland Revenue unless he be an expert accountant and very ready with his pen. Deficiencies in other respects may probably be got over by diligent self-culture, especially if the candidate be of steady industrious habits, and not given to take offence on trivial grounds, or to resent fancied injuries ; but no qualifications can compensate for deficiencies in accounts and penmanship.

† The Commissioners of Inland Revenue recognise as one of their most important responsibilities the duty of keeping the service in a state of efficiency. To attain this object, a systematic examination is made of the performances and proceedings of each established officer before he can be advanced in rank ; and the duties of the various classes of officers are allotted

An *Expectant* is an officer who is employed to act for a regular officer when sick or absent. He has a fixed salary of 50*l.* per annum, and when employed, receives an additional allowance at the rate of 30*l.* per annum. As vacancies happen, the expectants are appointed supernumeraries or assistants.

An *Assistant* is an officer whose duty usually is to watch the operations of a single trader, such as a soapmaker or distiller, when constant attendance is required. He is also occasionally employed to relieve established officers during any great pressure of business. His salary is 85*l.* per

to each in such a manner as to render these officers a constant check upon each other. The collector is a check upon the supervisor, and the supervisor upon the officer; and the vigilance and uncertain visits of the surveying general examiners (which are not permanent, but directed without any previous intimation on a given point) are intended to hold a perpetual check over the whole of the surveying department; and to render the system still more perfect, an officer is not promoted, when, from length of servitude, he would be eligible for a higher station, if there be any censure standing against him, nor unless he petition for such promotion. But having petitioned, his performances are subjected to a rigid examination in order to ascertain what his conduct has been in the rank he has hitherto held. (See *Rep. Ex. Inq.*)

It thus appears that, although an officer is eligible for advancement to the higher grades, his promotion is dependent, in a great measure, upon his own exertions; it should therefore be his constant study to conduct himself so that he may be found duly qualified when his period of advancement arrives. Formerly, instances have occurred of persons rising to the higher stations of the Excise, without being distinguished by any great mental acquirements, to say nothing of their moral character; but the commissioners have come to the determination to select for promotion, in future, only those officers whose character, talents, and acquirements, will do honour to the responsible stations they are designed to occupy.

An officer, from his first appointment to his highest promotion, ought to be a *student*. As soon as he receives his commission, he ought to make himself acquainted with the duties which he shall have to discharge, and the best mode of discharging them with credit to himself and advantage to the revenue. And as his time will not in all probability be fully occupied at first, he will do well to subject himself to a regular course of study of the different matters embraced in the present work. Many of these matters may, indeed, have formed part of his school education; but he should now go through them again, with reference to the bearings which they have upon his duties as a revenue officer. It is impossible for him to give too much attention to the principles of arithmetic, mensuration and gauging; for the more readily he can apply these principles to the duties of his profession, the more satisfactorily he will be able to undertake and discharge them, and the more likely will he be to rise to the higher grades in the service. He should also carefully study the laws under which the excise duties are collected, the heads of which will be found in subsequent pages; and from time to time he should carefully note every alteration which may be made in these laws, and the Orders which the Board may issue for his guidance. In these studies, he must

annum. A *Supernumerary* attends the collector on his rounds, carrying the official papers and assisting in the collection of the duties. His salary is 52*l.* per annum, and if he officiate for a surveying officer, he receives an additional payment, at the rate of 38*l.* per annum. As vacancies occur, assistants and supernumeraries are appointed to the next higher station, namely, that of a ride.

A *Ride-Officer* has to survey the excise manufacturers and traders within a certain extent of country in which they are thinly scattered, for which purpose he is required to keep a horse. His duty is to attend at the traders' establishments, and take an account of the different operations going on there, so as to ascertain to what extent

not be sparing of the use of his pen; but make copies or memorandums of every thing that engages his attention. He will thus improve his powers of composition as well as the character of his handwriting; and he ought to take especial care never to get into a careless or slovenly mode of writing or conducting his business.

When an assistant or supernumerary is appointed to be a stationary *surveying officer*, he ought still to continue to improve himself in writing, composition, book-keeping and correspondence; neglecting no means of improvement that come within his reach, and above all, applying himself to the diligent acquisition of sound principles of rectitude and morality, devoting his energies to the conscientious discharge of his duties and the good of the community. In this situation, great discretion is required in his intercourse with the traders under his survey. He is required by his instructions, by a civil and becoming behaviour, and by evincing a spirit of reasonable accommodation, to avoid giving any just occasion of complaint to any person with whom he is concerned by virtue of his office. He is especially prohibited from receiving rewards or treats of any description from the traders under his survey, and the necessity of attending to this prohibition cannot be too strictly impressed upon him. It is to be regretted that there should be any necessity for the caution; but, whilst all admit the dishonesty of receiving money from traders, it cannot be denied that many officers fail to see the impropriety of receiving advantages in other respects. Such officers are recommended to ask themselves, how they can show their independence before a person from whom they have received treats? If it be said that in offering an officer a treat, a trader does not want any unfair advantage, but only accommodation; it may be answered, that an officer who will not give a trader all the accommodation consistent with the faithful discharge of his duty, without being bribed to it, is unfit for his station. There is another thing which the surveying officer ought not to forget, viz. :—that it is no part of his business to receive the duties. The person to whom the duties are payable, and who is alone accountable for them to the revenue, is the *collector*. The subordinate officers are only *charging* officers, and they are strictly prohibited from handling the duty in any shape or under any pretence whatever. The law imposes upon the traders the necessity of conveying the money to the collector at his sittings; and the Board have, by repeated and very stringent Orders, endeavoured to make the subordinate officers understand, that they are not to take the money from the traders, either under pretence of

the duty is chargeable ; and at the proper periods he has to assess the amount of such duty, and return an account thereof for the collector, in order that he may receive it on his rounds. The officer has also to make a return of the traders in his ride who are subject to excise licences, with the amount payable thereon. He is required to enter in proper books an account of all his proceedings, and is at all times subject to a strict vigilance on the part of his superior officers. His salary is 100*l.* per annum, and he is seldom allowed to remain in one place more than four or five years. After a ride-officer has been three years employed, the last of which has been in a ride, he is at liberty to petition for promotion, and if no censure is recorded

conveying it to the collector, or on any other account; and no officer who values his situation or the welfare of his family, will lend himself to the breach or even to the evasion of these reasonable regulations.

Before an officer becomes an *Examiner*, he must have been seven years in the service, and probably a much longer period. If he be a person of observation, he will in that time doubtless have made himself acquainted with the general nature of the business of a supervisor. Still, there are many points upon which his attendance in London will afford him the means of improvement. In the day-time, he ought to lose no opportunity of becoming acquainted with the routine of the different offices in the establishment; and his evenings should be employed in reviewing his mathematical and literary attainments, and in supplying any deficiencies in his education or mental culture, for which the metropolis affords so many facilities. He should recollect that he is now preparing to rank in a station of more importance, and that his performances will be continually, in one shape or other, under the immediate observation of the commissioners, upon whose approbation his success in life depends. And under this feeling he should determine to discipline himself, and act in such a manner, that he may never be afraid or ashamed of their severest scrutiny.

Supervisors have not much time for study if they perform their duties according to the letter of their instructions: still, if they intend to rise further in the service, they must contrive to improve their theoretical and practical knowledge in Excise matters, and, if possible, to add to their literary and scientific attainments. As it is, there is not, in this country, a class of more hard-working, painstaking people, than supervisors; and, generally speaking, they are amongst the most meritorious and useful members of society. According to the present system, they are, perhaps, kept too much in a state of suspicion and terror, which from them is spread amongst their inferior officers. A supervisor ought to know that his own interest consists not in any undue severity upon his officers. By treating them with candour and kindness, warning them when they are in error, and encouraging them when they are desirous of doing right, a supervisor will generally find that his officers will reciprocate his candour and kindness, and his conduct will, in the end, be duly appreciated by his superiors. It is, however, of no use attempting to screen a careless, drunken, profligate man. The sooner such a person is out of the service the better for all parties.

against him, his "books are ordered out for examination" for a quarter of a year previously; and should it appear that his book-keeping has been correctly performed, his traders properly surveyed, and his gauges and accounts accurately made up, he is appointed a division-officer on the first vacancy.

A *Division-Officer* has the superintendence of a more limited, but more closely populated part of the country than a ride-officer. The general character of his business, however, is of the same description, and his salary is of the same amount; only he is not required to keep a horse. A division-officer after having been seven years in the service, the last three of which have been in a division, is eligible to petition to be made an Examiner, and if there be no censure standing against him, his petition is recorded; but his request is not granted as a matter of course. When there are a number of vacancies, the claims of the several candidates for promotion are considered by the Board, and a selection made of such as, from the character of their handwriting and correspondence, appear to be most eligible; and when any candidate is selected, his books for three months are again ordered out for examination, and his performances subjected to a rigid inspection. Should the result be favourable, the officer is ordered to attend at the chief office in London, where he is personally examined by the surveying general examiners as to his grammatical proficiency, general acquirements, and knowledge of the excise laws and instructions; as to his ability to write fluently and correctly from dictation; and as to his proficiency in arithmetic, including vulgar and decimal fractions. He is also required to draw up some reports to the Board in the form of statements of complaints against traders, in order that his handwriting and capacity for correspondence may be tested; also to make calculations showing the average strength of spirits of various strengths and their reduction to proof; and to compute the average gravity of worts of different gravities, when mixed together. He is likewise examined by the

accountant-general as to his knowledge of book-keeping by double entry. The results of these examinations, including the candidate's original report, &c., are laid before the Commissioners, and should they be satisfied therewith, he is appointed an examiner.

An *Examiner* is an officer who is employed at the chief office for the purpose of examining officers' books, and qualifying himself for the duty of supervisor. He is also sent into the country, when necessary, to officiate for any supervisor who may be out of business through illness, or any other cause. His salary is 150*l.* per annum; and when he is employed in the country he receives an additional allowance, at the rate of 50*l.* per annum. As vacancies occur, examiners are appointed in rotation to be supervisors.

A *Supervisor* has the charge of a district comprising a certain number of rides and divisions. His principal duty is to survey the traders, and check the performances of the officers in his district. He has also to report to, and correspond with the Board, and the heads of departments, upon all matters connected with the business of his district. His duties are very heavy and onerous; and he has to keep a diary of his daily performances, which is periodically reported upon by his collector, and afterwards read and examined by the Board. His salary is 200*l.* per annum; out of which, if his district be wide, he has to keep a horse. After a supervisor has been appointed three years he is eligible for the station of surveying general examiner, and after five years he may be appointed a collector. These appointments, however, are not by rotation; but are given, as vacancies occur, to those supervisors whom the commissioners consider most meritorious and eligible. When the selection falls upon any particular individual, he is ordered to attend at the Chief Office for examination; and he is there required to compose a "Theme" upon some subject connected with the law or practice of Excise; and to prove himself a proficient in the art of composition; and to have a practical know-

ledge of revenue matters generally : and should his efforts in this respect be successful, his books are ordered out for examination. This examination extends sometimes over a period of twelve months, and includes not only the supervisor's own books, but also those of the officers of his district ; he being held responsible for any errors that may be discovered in any of them. When the examination is finished, his "character" is read to the Board, and, if approved, he is appointed a Surveying General Examiner.

A *Surveying General Examiner* has no particular district under his charge, but is employed either at the Chief Office in London, in reporting upon questions of difficulty relating to the rates of duty payable on different articles, or the management of the establishment ; or, in the country, in investigating special matters relating to traders or officers, or surveying, as a check upon the proceedings of the supervisors and surveying officers. Surveying general examiners are divided into four classes ; the first and third being employed almost exclusively in the Chief Office : and the second and fourth being most of their time engaged in the country. The classes and salaries are as follows :—First class, one at 550*l.*; two at 500*l.*; and two at 450*l.* Second class, one at 400*l.*; and sixteen at 350*l.* Third class, one at 350*l.* ; and four at 300*l.* Fourth class, six at 300*l.* ; and fourteen at 250*l.* The appointments to the higher classes are made by selection from those in the lower. Surveying general examiners, without distinction of class, are also selected and appointed to be collectors as vacancies occur.

A *Collector* is at the head of a particular collection or tract of country, including districts, rides, and divisions. His business is to collect and account for the duties accruing within his collection. For this purpose he is required at stated intervals—eight times in the year—to visit, and hold a sitting for the receipt of excise duties, at every market town in his collection ; and being there attended by his supervisors and officers, he receives the duties which the traders

are required to bring to him. He also inspects the supervisor's diaries, and hears and reports upon the officers' explanations of any complaints which may be stated against them. In England and Scotland the collectors now receive the assessed and other taxes from the local collectors, and in Ireland they receive the crown or quit rents. When not on his "rounds," the collector is employed chiefly in making up and transmitting his voluminous accounts and returns. He has likewise a general supervision of the conduct of his inferior officers, and is sometimes employed in investigations similar to those intrusted to the surveying general examiners. The salary of a collector varies from 350*l.* to 600*l.* per annum.

Besides this general course of promotion there are some *fixed offices*, to which the officers of the surveying department of different ranks are considered eligible. Thus, the under-secretary, assistant-secretary, correspondents, and head port-surveyors are usually made from the ranks of surveying general examiners. The permit-inspector, clerk of the diaries, and assistant port-surveyors are made from supervisors; collector's clerks from division officers; and various port-officers and permit-examiners from division or ride-officers.

All persons employed in the Excise are *prohibited* from interfering in the election of members of Parliament, and from receiving bribes or rewards in connexion with their business; and also from carrying on any business or manufactory subject to the Excise laws. On the other hand, they are *exempted* from serving in the militia, or on juries, or in corporate or parochial or public offices, and from taking parish apprentices; and no action can be brought against them without previous notice. A *deduction* or *per centage* is made from official salaries towards the Government Superannuation Fund; and, in return for this, when an officer retires from the service on account of age or otherwise, an annual *retiring allowance* is made to him proportioned to his length of service, &c. In connexion with the Excise

Establishment there is also a *Life Assurance and Widows' Fund*, but it is not compulsory on the officers to subscribe to them.

To enable the officers properly to assess and secure the Excise duties, various *regulations* are prescribed by law.*

* For an abstract of these laws, and an account of the present duties, drawbacks, and allowances, see Appendix.

The traders subject to the Excise survey have been divided into six classes : 1st, persons visited for the purpose of charging the "growing duties," as maltsters, soap-makers, paper and pasteboard-makers, distillers, hop-planters, and postmasters who let horses for hire ; 2nd, persons whose licenses are high or low, according to the extent of their manufacture, as brewers, maltsters, tobacco manufacturers, &c. ; 3rd, persons who are not only liable to Excise license, but are also subject to a survey for the purpose of preventing the illegal mixture of duty-paid with unduty-paid articles, as rectifiers, tobacco manufacturers, malt-roasters, &c. ; 4th, persons visited, because subject to a license for dealing in articles upon which the Excise duty has or ought to be paid, as inn-keepers who are retailers of spirits ; 5th, persons visited in like manner, because subject to a license for dealing in articles upon which customs duty has or ought to have been paid, as dealers in tea, coffee, pepper, tobacco, snuff, foreign wines and spirits ; and lastly, persons from whom no duty for license or otherwise is collected, but who are surveyed as a check against their making or receiving unduty-paid articles, as tallow-melters, &c.

The duties, except those on licenses and post-horses, are charged by the officers, who visit the places where the commodities are manufactured or prepared. The general system is, to obtain an account of the materials intended to be used, or the earliest possible account of the commodity itself after the process has commenced, and to charge the duty in the stage in which the most certain and satisfactory account of the quantity produced can be obtained. The accounts taken before, and sometimes after, the charge has been made, are intended to prevent the manufacturer from sending any part of his commodities into consumption before the duty has been charged, and introducing fresh materials in the place of the commodities withdrawn. In most cases, the manufacturer is required to give notice to the officer before he commences an operation, and the officer is enjoined to attend at the premises where the most useful accounts can be taken, and on every visit to go through the entered premises, and to record in his survey-book the state of the materials in the process of manufacture, and the quantity, in certain cases, when it can be ascertained, and may be useful, in checking the quantity afterwards produced for charge. From these surveys and entries, the charge of duty is ultimately made upon the trader, with whom an account of such duty is left before the time of payment, which, in the usual course of business, is at the collector's round or sittings for the district in which the premises are situate. In many cases, a paper is required to be kept on the traders' premises, called a "specimen," in which the officer is required to make entries, corresponding in substance with the entries in his survey-book, and in other cases a "minute paper" is required to be signed on every survey, to show that the officer has given due attendance. The several charges upon each trader having been recorded in the officer's books as they are made, the whole are added up, and returns thereof are made eight times in the year ; namely, at the close of each quarter, that is, 5th April, 5th July, 10th October, and 5th January ; and also at about the middle of each of these quarters ; and in

Every Excise trader is required to make an *entry* of the premises used for carrying on his manufactory or business, and sometimes also of the utensils used in such manufactory or business; and the officer is authorised to enter and

some instances more frequently. When all the charges have been made up, the officer transcribes the total amount of each person's charge from the book into an account called a "voucher," one of which is made out for each separate duty, namely, malt, soap, &c. The charges on the several traders contained in each voucher are then added up, and the total is the amount of that particular head of duty arising within the station. The duty so arising is computed and set out in the vouchers, from which the officer prepares an account called an "abstract," containing the total amount of the commodities charged on every trader in his division or ride, and the duty thereon. These accounts are compared with the books and examined by the supervisor, who forwards the abstract to the collector, to apprise him of the sums with which he will be charged by the accountant at the chief office, and the names of the persons from whom he is to receive the same. The supervisor next transmits to the chief office the vouchers, which are the foundation of the charge there raised against the collector.

Every collector in the United Kingdom commences the collection of the duties (technically called his round) on the same day, which is fixed by the Board, commencing about nine days after the officers have made up their respective books; and at the different places where he holds his sittings, the sums paid to him by the respective traders are discharged in the ledger by the collector's clerk; and those charged, and for which the credit allowed by law has not expired, are set forward as "uncollected," to be paid as they become due; and the sums which have actually become payable, and are not paid at the proper time, are arrears, and an account of them is kept separate for inquiry or proceedings. When the business of collecting is over for the day, each officer is required to make out an account in his own book of the different sums arising within his business which the collector has received that day, and another account showing, under each head of duty, the amount of arrears outstanding against each trader; and these accounts having been compared and examined, the former is signed by the officer and the latter by the collector and supervisor. The total sum received by the collector in each station is entered by the officer, in his own figures, in a sheet called the "Collector's Petty Account," and signed by both officer and supervisor. Each officer also enters in the respective arrear lists for each duty the amount of arrears outstanding in his business, which lists, after they have been examined by the supervisor, are sent by him to the proper accountant at the chief office. All monies collected are remitted by the collector to the receiver-general in London, and the collector is not allowed to retain any balance in his hand at the end of any week if it can be avoided, unless on the authority of the Board, which is granted to meet only special advances of cash or payments likely to be soon demanded. The collector has also to send up one of the petty accounts at the close of each week, in order that it may be seen what sums have been received by him in that week, and the manner in which the money has been applied (*i.e.*), whether by remittances, repayment of duty, allowances, or drawbacks, &c., &c., or in charges of management, for all of which he has to transmit the proper vouchers; and if any material balance remains in his hands at the end of the week, an explanation is required to accompany the account, and the date of the Board's order, if any, authorising its retention. The money remitted to, or received by, the receiver-general is paid into the Bank of England, and ultimately transferred into the Exchequer.

remain on such premises, for the purpose of "surveying" and gauging such utensils, and taking an account of the different articles in process of manufacture. In certain cases, also, the trader is required to give *notice* to the officer before he commences or takes certain steps in his operations. In case of fraud or breach of regulations, *penalties* and *forfeitures* are incurred; and in many cases the officers are empowered to seize the fraudulent articles.

The duty on *Spirits* is charged at so much per gallon, namely, in England, 7*s.* 10*d.*; in Scotland, 3*s.* 8*d.*; and Ireland, 2*s.* 8*d.* The duty is not charged by actual admeasurement of the spirits, but upon the quantity found, according to a certain standard of strength, called "proof," as denoted by the hydrometer, called "Sikes's Hydrometer." There are three modes of charging the duty; 1st, upon the *wash* used in distilling, one gallon of proof spirits being charged for every hundred gallons of wort for every five degrees of gravity attenuated; 2nd, from the quantity of proof spirits on the *low wines*, two per cent. being allowed in England, and five in Scotland and Ireland, for waste arising from the distillation of low wines into spirits and feints; 3rd, from the quantity of *proof spirits* contained in the spirits and feints produced from the distillation of the low wines. The distiller is charged with duty on the greatest quantity arising from any one of those modes of charge; besides which, if, at the expiration of his license, he shall not have been charged for one gallon of proof spirits per cent. of wash for every four or five degrees of the gravity of wort, according to the materials employed, he is then chargeable with duty on the quantity deficient. In order to obtain a correct account of these various operations, the officer has to gauge the utensils, and frequently to survey the premises and utensils, and their contents: and during the time that distillation is going on, an officer or an assistant is constantly in attendance. After the process has been completed, a Dr. and Cr. account is kept of all the spirits in the

distiller's stock, and none are allowed to be sent out without permit. In Scotland or Ireland spirits may be warehoused without payment of duty, until they are taken out for consumption or removal. If removed from Ireland to Scotland or England, or from Scotland to England, a countervailing duty is payable at the port to which they are removed. Countervailing duties are also charged on spirit mixtures and sweets, on removal from one part of the kingdom to the other. Spirits, whether foreign or British, can only be removed (in quantities exceeding one gallon) with a permit or certificate accompanying them. Rectifiers are under the survey of the Excise officers; and the stocks of dealers and retailers are subject to inspection. The officers are also authorised to search for and seize private stills, and to stop and examine packages suspected to contain spirits; the object being to prevent the manufacture and consumption of spirits which have not paid the Excise duty in this kingdom, or the customs duty on importation.

The duty on *Malt* is charged at the rate of 2s. 7d. per bushel, and 5l. per cent.; but the charge is made not by actual admeasurement, but according to the largest quantity found by gauge in any of its stages of operation after the following deductions have been made; namely, 18½ per cent. from the quantity of corn found in the cistern or couch; and one-half from the quantity found on the floor or kiln. To enable the officer to make these charges correctly, he gauges the different utensils used, and takes an account of the barley or other corn in its various stages of operation; the maltster being required to give notice when such operations commence, and to lay his grain in such a manner that it may be conveniently gauged by the officers. The proper security of this duty forms an important part of the business of the great body of surveying officers.

The duty on *Soap* is charged at the following rates per pound; namely, hard soap, 1½d.; soft soap, 1d.; with 5l. cent. additional. On soft soap, the duty is charged by

actual weight, it being weighed in the barrels into which it is placed after it is taken out of the coppers. On hard soap, the duty is charged, not by actual weight, but according to the quantity found by gauge when it is in the frames into which it is cleansed from the coppers; the gauge being taken in cubic inches, on a calculation that 28 inches when hot, and 27·14 when cold, are one pound, when the soap is made from ordinary materials of tallow, kitchen stuff, oil, resin, and alkali, or any mixture thereof; and that 26·76 inches when hot, and 25·91 when cold, are one pound, when the soap is made from such materials in a high-pressure boiler, without fitting or finishing in any other copper; and that 24·04 inches when hot, and 23·30 when cold, are one pound, when the soap contains any silicious or earthy matter, or any substance or matter other than the usual or ordinary materials. To obtain an accurate account of the quantity of soap made, the officer attends the soap manufactory on notice, which the trader is required to give; and when the operations require the coppers to be opened, an officer is in constant attendance. At other times the coppers are under the locks of the revenue. There being no duty on soap in Ireland, if any be removed from that country to England, it is subject to a counter-vailing duty.

The duty on *Paper* is charged at the rate of $1\frac{1}{2}d.$ per pound, and 5*l.* per cent. additional, according to the actual weight found when it is tied up and labelled to be sent out for consumption. The officer surveys the premises at intervals during the time the operation is going on, his chief object being to see that no paper is made or sent away without being properly labelled and charged with the duty.

The duty on *Hops* is charged at the rate of $2d.$ per pound, and 5*l.* per cent. additional, upon the actual weight found, the hops being weighed and charged when they are dried and bagged, ready to be sent out for consumption. The gardens in which the hops are grown are surveyed some time before the time of hop-picking; and the places in which

they are deposited for drying, are also surveyed until the duty is charged ; the chief object being, as in the case of paper, to prevent any from being removed without payment of duty. As this survey is limited to a certain portion of the year, extra officers are employed for the purpose, at the rate of 80*l.* per annum. There being no hop-duty in Ireland, if any are removed to England, they are charged with a countervailing duty.

The duty on *Sugar* made in the United Kingdom is charged at the rate of 10*s.* per cwt., according to the quantity of juice or syrup made in proportion to the declared gravity of such juice or syrup, or to the quantity ascertained according to its specific gravity, after allowing 50 per cent. for molasses, drainage, and wash. For ascertaining the correct quantities, the officer surveys, and takes an account of the different operations : but the quantity of sugar made in this kingdom is very limited at present. If sugar be used in brewing beer for sale, it is liable to an Excise duty of 1*s.* 4*d.* per cwt.

The duty on *Post-Horses* let for hire is charged at different rates (amounting to about one-fifth of the amount paid for the hire) upon the accounts or returns of the postmasters themselves. The officers make no survey for securing this duty, further than attending at the Postmaster's premises to inspect his returns, and at the different toll-bars to take up the tickets, which are afterwards used for checking the returns.

The duty on *Stage Carriages*, at 1½*d.* per mile, is charged upon the returns of the proprietors ; and the duty on *Railways*, at 5*l.* per cent. on the sums received for the conveyance of passengers, is calculated from the official books of the different Companies.

The duty on *Licenses* is charged when the licenses are granted to the traders, which in most instances is done at the collector's sittings, held nearest to the time when the old licenses expire. The officer's duty is to see that no Excise

trader carries on business without license, and to give notice to the traders of the time when the duty must be paid to the collector. In the case of brewers, the duty on whose licenses is in proportion to the quantity of beer brewed, the officer has to survey the premises in order to ascertain the proper amount payable. And in every case he has to enter the particulars in his survey-book, and furnish a proper list to the collector, in order that he may know what sums to receive from the trader.

There is no excise duty on *Tobacco*, but tobacco manufacturers and dealers are under the survey of the officers of Excise; the object being to prevent smuggling or adulterations, and thus to protect the revenue of customs to which a duty is payable on importation. With a similar object the Excise officers are empowered to detect adulterations in *Tea, Coffee, Cocoa, and Pepper*. And to protect the Excise duties on Malt and Hops, they are authorised to prevent the admixture of deteriorating ingredients with *Ale and Beer*.

On the exportation of certain excisable commodities *Drawbacks* are payable; but before the payment is made the parties are required to enter into bond and conform to various regulations; and it constitutes an important part of the duty of certain officers to see that these regulations are properly complied with.

For recovery of Excise duty in arrear, and penalties and forfeitures incurred, the *legal proceedings* are frequently before the magistrates in the country; in which cases the official documents have to be filled up and the proceedings conducted by the local officers.

Excise officers have also to attend to the *Corn returns* required by law to be made weekly; and are not unfrequently called upon to *report*, for government purposes, on matters not immediately connected with their current business.

It will be obvious, from the foregoing summary, that the business of an Excise officer is at once difficult and onerous;

and that for its satisfactory performance it not only requires unwearied diligence and undivided attention, but it also calls for the exercise of much skill and intelligence. An Excise officer ought to be a man of great general information ; and should be especially well skilled in the art of *Decimal Arithmetic*, in which the accounts of the revenue are kept, and in the various rules for shortening numerical calculations usually known by the name of Mental Arithmetic. He should be familiar with the *Sliding-rule*, that most invaluable instrument for casting gauges and checking arithmetical computations, and well acquainted with its use and application. He should be an adept in the practice of *Mensuration of Superficies*, so as to be able readily to calculate the areas of different figures in the denominations on which the duty is charged. He should also be well versed in the art of *Mensuration of Solids*, and especially its application to the gauging, inching, and tabulating of the different vessels used in distilleries and other Excise trades. He should be a ready penman and book-keeper, and is particularly required to have a competent knowledge of *Book-keeping by Double-entry*. And he should possess a sufficient knowledge of *Chemistry* to enable him to understand the manufactures or operations of which he has to take an account, and to detect the adulteration of the various articles which it is his duty to examine. To assist the officer in acquiring and applying this varied knowledge is the chief object of the following pages, of which a chapter is devoted to each of the subjects specified ; and at the end are appended a great number of tables, forms, hints, and summaries of a practical nature, which it is hoped will altogether constitute an efficient "Excise Officer's Manual," and a useful, if not an indispensable, "Gauger's Assistant."

CHAPTER I.

DECIMAL AND MENTAL ARITHMETIC.

ARITHMETIC * is the art of numbering and of calculating in numbers. It is usually divided into two parts, the one applying to *simple numbers*, and the other to *quantities* of different denominations, including in the latter division vulgar and decimal fractions.

A *Fraction* † is a part, or several parts, of something

* It is not intended to give a complete treatise on arithmetic, but only to introduce such rules and directions as will enable the officer (who is, of course, presumed to be conversant with the elementary rules of arithmetic) to apply his knowledge to the proper discharge of his duties. The accounts of the Excise being made and kept decimally, the rules in the text are applicable especially to that excellent method of computation; but they are not limited exclusively to it. Under the different heads there will be found suitable directions and examples for shortening the labour of calculation by common numbers, such as are usually inserted in arithmetical works under the head of Practice and Mental Arithmetic.

† Fractions, in an arithmetical point of view, are the aliquot parts or submultiples of an unit, which unit must therefore be divided into a number of equal parts, of which parts a certain number is to be taken. Fractions have generally their origin from remainders in division; thus, if 13*l.* be divided by 5, the quotient is 2 with a remainder of 3*l.* to be divided by 5. Each of the fifth parts of the 13*l.* is therefore 2*l.*, and 3 parts out of 5 of another pound, or 2*½l.*; but as each of these latter parts is less than a whole pound (the unit of the sum to be divided) it is, as it were, a *broken* quantity in comparison with such unit, and is therefore called a *Fraction*, while the pound in reference to the fraction is called the *Integer*. The lower number or denominator of a fraction shows into how many parts the original unit or integer is supposed to be divided or broken; the upper number or numerator shows how many such parts are in the fraction spoken of: thus, the fraction $\frac{9}{10}$, signifies nine parts out of ten into which the unit is supposed to be divided. If the numerator, in any case, equals or exceeds the denominator, it is called an *Improper* fraction: thus $\frac{11}{10}$ is an improper fraction, as it exceeds the unit or integer, and in reality signifies $1\frac{1}{10}$. If a number consists of a whole number and a fraction annexed, as $5\frac{3}{4}$, it is called a *Mixed Number*. Fractions of different denominations may be changed to the same denomi-

considered as a whole ; and, in what is termed common or vulgar fractions, is expressed by two numbers, one above the other, with a line between them ; thus, $\frac{1}{2}$ (one-half), $\frac{1}{3}$ (one-third), $\frac{1}{4}$ (one-fourth or one quarter), $\frac{4}{5}$ (four-fifths), $\frac{9}{10}$ (nine-tenths), &c. ; the upper number being called the *numerator*, and the lower the *denominator*.

The lower denominations of *Weight, Measure, Time, and Money*,* are fractional parts of the higher ones ; and some-

nation by multiplying the numerator and denominator of each fraction by the denominators of all the other fractions. Thus, to change $\frac{1}{2}$, $\frac{1}{3}$, and $\frac{1}{4}$ to the same denominator, we multiply both terms of $\frac{1}{2}$ by 3 and 4 ; both terms of $\frac{1}{3}$ by 2 and 4 ; and both terms of $\frac{1}{4}$ by 2 and 3 = $\frac{3}{6}$, $\frac{2}{6}$, and $\frac{3}{12}$. And to reduce a fraction to its lowest denomination, we divide both terms by the largest number that will leave no remainder : thus, to reduce $\frac{3}{12}$ to its lowest terms, divide both terms by 12 = $\frac{1}{4}$. The common divisor is obtained, when not obvious, by dividing the denominator by the numerator, and the numerator by the remainder, and the last divisor by the remainder again, and so on until nothing remains ; the last divisor is the common divisor.

* If the scale of every article (whether money, goods or time) were constructed on a principle of decimals, as is the case to a great extent in some foreign countries, the calculation of the value of such articles, or of any number of them, or any portion thereof, would be comparatively simple. In this country, however, where different scales are used for different kinds of articles, these calculations necessarily involve much labour and difficulty ; and it is obvious, that before they can be entered upon at all, the operator must be perfectly acquainted with the different scales referred to.

For arithmetical purposes, these scales may be brought under the several heads of money, weight, measure and time. For *Money*, the pound or sovereign is the standard ; and there is a series of inferior coins advancing irregularly from a farthing upwards ; as 2 farthings 1 halfpenny ; 2 halfpence or 4 farthings 1 penny ; 12 pence 1 shilling ; 20 shillings 1 pound.

Weight determines the quantity of matter that is in anything. The standard from which, (considered as unit), all measures of weight are to be computed, is the imperial standard troy pound. This standard, if lost, is to be restored by the following calculation :—If a cubic inch of distilled water be weighed in air by brass weights at the temperature of 62 degrees of Fahrenheit's thermometer, the barometer being at 30 inches, it is equal to 252.458 grains ; and 5760 of such grains are to be a pound weight troy (5 Geo. 4, c. 74, s. 5). The proportions of troy and avoirdupois weights, as regulated by the Act last cited, s. 4, are as follows : One twelfth part of the pound to be an ounce ; one twentieth of such ounce a pennyweight, and one twenty-fourth of such pennyweight a grain ; so that 5760 such grains are a troy pound, and 7000 such grains (= 27.7274 cubic inches of distilled water weighed as above directed) are a pound avoirdupois, the proportion between a pound troy and a pound avoirdupois being as 144 to 175 ; one sixteenth of the pound avoirdupois is an ounce, and one sixteenth of such ounce a dram. And by 5 & 6 W. 4, c. 63, s. 11, it is declared that 14 pounds are one stone ; 8 stones one hundredweight ; and 20 hundredweight one ton. *Specific gravity* is the relative weight or gravity of any body or substance considered with regard to some other body which is assumed as the standard of comparison. Rain-water, in consequence of its being less subject to variation than any other body, has been taken as this standard ; and by a fortunate coincidence, it happens that a cubic foot of

times are expressed as in vulgar fractions, with a numerator and a denominator : thus $2\frac{1}{2}d.$ signifies two pence, and one half of another penny. In most cases, however, the denominator is not expressed, but implied by an abbreviation : thus $2s. 6d.$ signifies $2\frac{6}{12}$, the denominator having reference to the number of pence in one shilling.

rain-water weighs 1000 ounces avoirdupois, very nearly, at the heat of 60 degrees by Fahrenheit's thermometer. At this heat, therefore, a cubic foot of rain-water is called 1000, and it is indifferently expressed 1000, or decimally 1·000 ; and when we speak of the specific gravity of any other body, we express it in figures, which show how much more or less than 1000 ounces of such body are in a cubic foot ; or, which is the same thing, how much heavier or lighter it is than water.

Measure is of three distinct kinds. 1st, Simple extension, or *lineal* measure. 2nd, Surface, or *superficial*, usually called "square measure." 3rd, Solidity, or *capacity*, usually called "cubic, or solid measure." The standard from which (considered as unit) all measures of extent, whether lineal or superficial, are to be computed, is the "imperial standard yard," which, if lost, is to be restored by a pendulum vibrating seconds at London (*in vacuum*), in the proportion of 36 to 39·1393. (5 Geo. 4, c. 74, s. 3.) The proportions of *lineal* measure, as regulated by the Act just cited, s. 1, are as follows :—One third part of the standard yard to be a foot, and the twelfth part of a foot an inch ; the pole, or perch, to contain $5\frac{1}{2}$ yards, the furlong 220 yards, and the mile 1760 yards. The proportions of *superficial* measure, declared by the same Act, s. 2, are as follows :—The rood of land is 1210 square yards, and the acre 4840 square yards, being 160 square perches, poles, or rods. The standard from which (considered as unit) all measures of *capacity*, as well for liquid as for dry goods, are to be computed, is the "imperial standard gallon," containing 10 lbs. weight avoirdupois of distilled water, weighed in air at a temperature of 62 degrees of Fahrenheit's thermometer, the barometer being at 30 inches (5 Geo. 4, c. 74, s. 6) ; consequently the pint will hold $1\frac{1}{4}$ lbs., and the bushel 80 lbs. ; and as 1 lb. avoirdupois is equal to 27·7274 inches (*vide supra*), a gallon, or 10 lbs., = 277·274 inches ; and a bushel, or 80 lbs., = 2218·192 inches. The proportions of the measure of *capacity*, as regulated by the section last cited, are as follows :—The quart to be the fourth part of the standard gallon ; the pint the eighth part of such gallon ; 2 gallons 1 peck ; 8 gallons 1 bushel ; and 8 bushels 1 quarter.

Time is the measure of motion and the succession of thoughts ; the year being divided into 365 days for common years, and 366 days for leap years ; the day into 24 hours, the hour into 60 minutes, and the minute into 60 seconds.

For the purpose of saving time in calculations, these various matters are reduced to tables, the most useful of which are inserted in the Appendix. Thus, Nos. 1 and 2 relate to money ; 3 and 4 to time ; 5, 6, and 7, to avoirdupois weight ; 8, 9, and 10, to measures of capacity for liquids ; 11, 12, and 13, to measures of capacity for dry goods ; 14, 15, 16, and 17, to lineal, square or superficial, cubic or solid, and angular measure respectively ; and 18 to miscellaneous weights and measures. Table 19 is a table of the specific gravities of different bodies found, as already observed, by comparing such bodies with rain-water. The comparison is made as follows :—It is found that a solid body when weighed in water *loses* of its weight a quantity precisely equal to the weight of its own bulk of water. To find the specific gravity of any solid body, therefore, we must divide the weight found on

A *Decimal* * is a fraction, the denominator of which is always 10, 100, 1000, &c.—that is, 1, with a cipher or a number of ciphers annexed; the denominator not being written under the numerator as in vulgar fractions, nor expressed by the abbreviated prefix as in mixed numbers, but implied by a point or dot placed before the numerator. Thus $\cdot 1$ is $\frac{1}{10}$, $\cdot 55$ is $\frac{55}{100}$: the value of the places decreasing in a *tenfold proportion below unity* in the same manner as they increase in whole numbers above unity. The ciphers, in fact, perform the same office as they do in whole numbers—that is, they fill up vacant places, and by that means, keep the significant figures in their proper stations and preserve their just value. But it is important to

weighing the article in air by the loss of weight in water; the quotient is the specific gravity. And so, in the case of a fluid, the specific gravity is equal to the weight lost by any solid body when immersed in it. Therefore, to find the specific gravity of any such fluid, we have only to weigh in the air and in the fluid, respectively, a solid body whose specific gravity is known, and to divide the product of the lost weight, and the specific gravity of the solid body, by the absolute weight of such body; the quotient is the specific gravity of the fluid. It must be observed that the heat at which water is to be weighed for finding the standard established by the Act of Parliament, is 62° ; and at this heat $27\cdot 7274$ cubic inches = 1 lb., and 1 inch = $\cdot 03606$ lbs. The heat at which the weight has been taken for comparing specific gravities is 60° , and at that heat a cubic foot of water has been assumed to weigh 1000 ounces; at which rate $27\cdot 648$ cubic inches = 1 lb., and 1 inch = $\cdot 03616898148$ lbs. To use the table of specific gravities in finding the weight of any body, the tabular number is usually multiplied by the foregoing decimal $\cdot 03606$ (although properly, the other decimal $\cdot 03616898148$ should be used); the product is the weight of a cubic inch of that body in pounds avoirdupois; and if this product be multiplied by the number of cubic inches contained in it, the result will be the weight in pounds of the whole body.

* Although the common way of expressing fractions when performing operations with them is that which accords strictly with the way in which fractions are naturally produced, yet it is attended with considerable trouble in consequence of there being as many denominators of fractions as there can be different numbers used for denominators. In order to avoid this trouble, a simple and beautiful system was invented (by Peter Ramus, 1586, as is generally supposed), in which, as in whole numbers, the same figures of the numerators are always of the same denomination, and can be added or subtracted without any change. Fractions in this form are called *decimals*, because the denominator always consists of as many tens (*decems*) multiplied together as there are figures in the numerator. And this not only saves the trouble of changing the fraction, but it also avoids the necessity of writing the denominator. The use of decimals in a great measure supersedes the common method of calculation; for not only can all questions in common arithmetic be solved by this mode of calculation, but in most cases the operations are easier and more satisfactory. The value of numbers, when used decimally, is shown in the following table; in which the first seven figures are

observe, that ciphers added to decimals on the right hand cause no difference in their value ; although when placed on the left, they diminish the value of the decimal in a tenfold proportion.

I. REDUCTION.

The first thing necessary to be understood in these operations is, how to reduce vulgar fractions and other broken quantities into decimals ; that is, to ascertain the value or notation of such fractions or broken quantities when expressed in decimals. The rules for effecting this purpose, and for again converting the decimals into fractions or other

integers, and the last six decimals, the dot being placed after the unit figure of integers to distinguish the fraction from the whole number :—

	Millions						Hundreds of Thousands		Tens of Thousands		Thousands		Hundreds		Tens		Units		Tenth parts		Hundredth parts		Thousandth parts		10 Thousandth parts		100 Thousandth parts		Millionth parts	
Places . .	7	6	5	4	3	2	1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Examples	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4

A decimal, when it stands alone, is distinguished from a whole number by having the point on the left of it: thus, 5 is a whole number ; but $\cdot 5$ is a decimal, signifying five-tenths. And when a number consists partly of whole numbers and partly of decimals, the point is always placed between the whole number and the decimal, as in the table: thus $5\cdot 5$ signifies 5 and five-tenths. Regarding decimals as fractions, the point is always placed to the left of as many figures of the numerator as there are ciphers in the denominator: thus $\frac{1}{10}$, $\frac{23}{100}$, $\frac{156}{1000}$, are written respectively $\cdot 1$, $\cdot 23$, $\cdot 156$. And should there not be as many figures in the numerator as there are ciphers in the denominator, the deficiency must be supplied by prefixing ciphers to the numerator: thus $\frac{3}{100}$, $\frac{4}{1000}$, $\frac{1}{10000}$, are written respectively $\cdot 03$, $\cdot 004$, $\cdot 00005$, &c. In making calculations with decimals, the same process must be observed as in operating with whole numbers: thus $\frac{1}{2}$ or $2\frac{1}{2}$ being converted into decimals, become respectively $\cdot 5$ and $2\cdot 5$, and for the purposes of addition, multiplication, &c., are treated as if they were 5 and 25. The chief thing to be attended to is the proper placing of the decimal point, as an error of a single figure in this respect alters the value in a tenfold proportion.

denominations, are usually classed under the head of reduction.

I. *To change a vulgar fraction into a decimal.**—Find some number, which being multiplied by the denominator will produce 1 with ciphers annexed, and the product of this number and the numerator will be the decimal. Or (which is the same thing), add a cipher or ciphers to the numerator, divide by the denominator, and the quotient will be the decimal.

II. *To reduce the lower denominations of money, weight, measure, or time, to a decimal.†*—Bring the lower denomina-

EXAMPLES IN RULE I.

(1.) Reduce $\frac{1}{2}$ to a decimal.

2)10(.5 Ans.

(2.) Reduce $\frac{3}{4}$ to a decimal.

4)3.00(.75 Ans.

In these examples the decimal point is placed immediately before the quotient. Should it be necessary to add more than one cipher to the numerator before the denominator can be contained in it, the quotient will require one cipher to be prefixed to it for each cipher required after the first, as in the following example :—

(3.) Reduce $\frac{1}{200}$ to a decimal.

200)1.000(.005 Ans.
1.000

(4.) What is the decimal of $\frac{3}{8}$?

Ans. .09375.

When the division does not terminate without a remainder, it is called either an interminate or a *circulating* decimal. It is obvious that, in such cases the greater the number of figures employed, the nearer it approaches to the true answer; although, after all, it can only be an approximation. Thus,

(5.) Reduce $\frac{1}{3}$ to a decimal. 3)1.000000(.333333.

(6.) What is the decimal of $\frac{1}{1000000}$? Ans. .098101265822784.

† EXAMPLES IN RULE II.

(7.) Reduce one shilling to the decimal of a pound.

One shilling being the $\frac{1}{20}$ of a pound, therefore— 20)1.00(.05 Ans.

(8.) What is the decimal of one penny (or $\frac{1}{4}$ of a shilling) ?

Ans. .0833.

(9.) What is the decimal of one ounce (or $\frac{1}{16}$ of a lb. ?

Ans. .0625.

If the denomination be less than the next immediate one to that in respect of which the decimal is required, it will be necessary before reducing it, to ascertain its proper fractional value, by reducing the required term to the same denomination as the given term, as in the following examples :—

(10.) Find the decimal of one penny as compared with a pound.

First reduce the pound to pence by multiplying it by 20 and the product by 12 = 240. And the question will then be—What is the decimal of $\frac{1}{240}$ of a pound? Which is found as follows :— 240)1.0000(.004166 Ans.

(11.) Reduce an inch to the decimal of a gallon and bushel respectively.

Refer to the Table of Measures of Capacity, No. 9, or make the necessary calculation, and it will be found that in a gallon there are 277.274 cubic

tion into a fraction of the higher, making the former the numerator, and the latter the denominator; and reduce such fraction to a decimal by the preceding rule.

inches = $277\frac{1}{277}$ and in a bushel 2218·192 cubic inches = $2218\frac{1}{192}$. Then—	
277·274)1·000000000(.003606 deci-	2218·192)1·000000000(.000451 deci-
831822 mal of an inch	5872768 mal of an inch
of a gallon.	of a bushel.
1681780	11372920
1663644	11090960
1813600	1813600
1663644	2218192

(12.) Reduce an inch to the decimal of a pound weight of the different kinds of soap respectively.

Ans. Common hard soap, hot ($=\frac{1}{27}$)·0357; cold ($=\frac{1}{27}$)·0368; high pressure, hot ($=\frac{1}{27}$)·0373; cold ($=\frac{1}{27}$)·0386; silitated, hot ($=\frac{1}{27}$)·0416; cold ($=\frac{1}{27}$)·0429.

(13.) What is the decimal of $0\frac{1}{4}$ d. ($=\frac{1}{4}$) of \$1? Ans. ·0020833.

(14.) What is the decimal of 2s. ($=\frac{1}{4}$) of \$1? Ans. ·1.

(15.) What is the decimal of 7d. ($=\frac{1}{4}$) of \$1? Ans. ·0291.

(16.) What is the decimal of $0\frac{1}{4}$ d. ($=\frac{1}{4}$) of \$1? Ans. ·00104166.

(17.) What is the decimal of 1 pint ($=\frac{1}{4}$) of a bushel? Ans. ·015625.

(18.) What is the decimal of 1 day ($=\frac{1}{365}$) of a year? Ans. ·00274.

If it be required to reduce numbers of different denominations to a decimal, the given numbers must be brought into the lowest denomination and the integer or integers into the same denomination; then add a cipher or ciphers to the former, and divide by the latter; or, the given numbers may be reduced one by one, beginning with the lowest. Thus,

(19.) Reduce 15s. 6 $\frac{1}{2}$ d. to the decimal of \$1.

20	15s.	6 $\frac{1}{2}$ d.	4)3·00
12	12		
240	186	or,	12)6·7500
4	4		20)13·56250
960)747·0	(·778125 Ans.		·778125.

In questions of this kind it is frequently unnecessary to carry the decimal places beyond the first three, and these may readily be found without multiplication or division, as follows: Take half the number of shillings for the first figure, and for the other figures increase the farthings by 1 if they amount to 24, and by 50 if there were a remainder in the shillings;—thus in the foregoing example, the half of 15 is 7 and 1 remains, and in 6 $\frac{1}{2}$ d., there are 27 farthings which, exceeding 24, is made 28; and this, because 1 shilling remained, is increased by 50 and becomes 78; hence the first three figures are 778.

(20.) Reduce 2s. 7d. to the decimal of \$1. Ans. ·12916.

(21.) Reduce 2s. 8 $\frac{1}{2}$ d. to the decimal of \$1. Ans. ·135.

(22.) Reduce 7s. 10d. to the decimal of \$1. Ans. ·3916.

(23.) Reduce 3s. 8d. to the decimal of \$1. Ans. ·1833.

(24.) Reduce 2s. 8d. to the decimal of \$1. Ans. ·1833.

(25.) Reduce 1 $\frac{1}{4}$ d. to the decimal of \$1. Ans. ·00625.

III. *To find a factor.*—Consider any given divisor to be the denominator of a fraction whose numerator is unity, and reduce such fraction to a decimal according to the foregoing

(26.) Reduce 3 bushels 1 peck to the decimal of 1 quarter. Ans. '40625.

(27.) Reduce $6\frac{3}{4}$ inches to the decimal of 1 yard. Ans. '1875.

(28.) Reduce the diameter of a circle to the decimal of its circumference, the former being to the latter, as $3\frac{1}{2}$ to 1 nearly, or $3\frac{1}{11}$, more nearly. Ans. '3181 or '31831.

Improper fractions and broken quantities exceeding an integer are reduced in the same way; thus—

(29.) Reduce $\frac{2}{3}$ to a decimal.— $20)25(1\frac{3}{5}=1\cdot25$ Ans.

If, in this case, the integer were a pound sterling, the question would be, what is the decimal of 25 shillings of a pound. Ans. £1'25.

(30.) Reduce £2 3s. $4\frac{1}{2}$ d. to the decimal of £1.

This is done by reducing both terms to the lowest denomination as in example (18.); thus, $1 \times 20 \times 12 \times 4 = 960$, and £2 3s. $4\frac{1}{2}$ d. $(\times 20 \times 12 \times 4) = 2081$. Then $2081 \div 960 = 2\cdot168$ Ans.

(31.) Reduce the circumference of a circle to the decimal of its diameter. Ans. 3'142857; or more correctly, 3'14159.

To save the trouble of calculation, the multipliers or component parts of the different denominations of money, &c., are inserted in the Tables already referred to. In like manner, most of the decimals answering to such component parts will be found in the same or other Tables in the Appendix: thus No. 2 is a Table of Decimals and fractional parts of a pound sterling for calculating prices, duties, &c. No. 6 is a Table of the fractional and decimal parts of a pound avoirdupois, and Nos. 10 and 12 are similar tables for a gallon and bushel respectively. Much time may frequently be saved by committing a few of the principal decimals with their corresponding fractions or denominational values to memory. For instance, if the student recollects that '25 = $\frac{1}{4}$, then as 5s. is $\frac{1}{4}$ of a pound sterling, 3 inches $\frac{1}{4}$ of a foot, 6 hours $\frac{1}{4}$ of a day, &c., he would not hesitate to write '25 for any of these. On the contrary, he would instantly conclude if he knew that '75 = $\frac{3}{4}$, that £'75 must be 15s. Then also '5 being equal to $\frac{1}{2}$ of any whole, £'5 must be 10s., '5 cwt. must be 2 qrs., and '5 lbs., 8 oz. avoirdupois. A few of the leading decimals are given in Table 20 in the Appendix, and it will assist the officer if he has them always at command. He should also recollect that most of these decimals with a proper sign affixed represent certain aliquot parts or even fractions of money, weights, and measures; thus 2s. 6d. is $\frac{1}{4}$ or '125 of a pound, 6s. 8d. is $\frac{1}{3}$, or '333 of a pound, &c.; and therefore, to ascertain how many half-crowns, &c., are contained in a given number of pounds, we have only to divide it by the decimal of the aliquot part. A number of these aliquot parts, as well as the aliquot parts of 100, representing the usual *per centages*, are inserted in Tables 21 and 23. The officer will likewise find it convenient to impress upon his memory the decimals of a pound sterling, representing the different rates of duty charged on exciseable commodities, see Table 22; and the decimals representing the value of a cubic inch as compared with a gallon, bushel, &c., see Tables 10 and 12. Many of the Tables, &c., prepared for officers of the revenue, are calculated for the measures in most common use; and it is desirable to know the readiest mode of converting the tabular number into numbers of other common measures: thus to reduce bushels to gallons, or gallons to bushels, it should be remembered that we have only to divide or multiply by 8, as the case may be. There is also a

Rule ; * the decimal thus found is a factor, which may be used instead of the given divisor.

fixed proportion between the number of solid inches in a bushel, and the number in a pound of soap of different qualities, which it is of importance to remember, especially in operations upon the sliding rule. See the Table of Factors, Divisors and Gauge Points, No. 30, in the Appendix.

* EXAMPLES IN RULE III.

A simple and useful application of the foregoing rules is to find a number, which, when used as a *multiplier*, produces the same result as would be produced by another given number, if used as a *divisor*, by which the tedious process of "long division" is avoided. The multiplier so found is called in technical language a "*FACTOR*," and is, in reality, nothing more than the *decimal* of the number which would otherwise be used as a *divisor*; such number being considered as the denominator of a fraction whose numerator is unity; or, in other words, it is the value of an unit of the divisor expressed *decimally*. Thus, if it be required to reduce ounces to pounds avoirdupois; to do this by the common method, the given number of ounces must be divided by 16, the number of ounces contained in a pound; but 16 involves a question in long division, for which it is desirable to find a substitute. Now, it will be seen by the foregoing rule, that .0625 is the decimal of $\frac{1}{16}$, or the value of one ounce expressed as the decimal of a pound; and it will be found, that if this decimal be used as a multiplier, the answer will be the same as if the given number of ounces had been divided by 16; thus, to find the pounds in 2360 ounces:—

By the old method.
16) 23600 (1475lbs. Ans.
16
—
76
64
—
120
112
—
80
80
—

By a factor.
23600
•0625
—
118000
47200
—
141600
—
1475•0000 lbs. Ans.

When the calculations are upon an extensive scale and involve the use of a great many figures, the saving of labour by the use of factors is very considerable, as may be seen by the following additional examples:—

The dimensions of excise utensils are all taken in square inches, but the accounts are kept in gallons and bushels. The number of inches in a gallon is 277•274 and in a bushel 2218•192, which numbers are the respective divisors for converting the square inches into gallons and bushels; but as these numbers are inconveniently large for that purpose, Tables have been framed, by reference to which the amount may be found by inspection, (See Nos. 36 & 37.) When the given numbers are not in the Table, it is still desirable to have a more convenient mode of calculation than dividing by the numbers referred to. And it will be seen by the operations in p. 27, that the decimals of these numbers respectively are •003606 and •000451. If we take these numbers and use them as multipliers or factors, the process of computation will be greatly facilitated. Thus, if it be required to find the number of

IV. *To reduce a decimal to a vulgar fraction.**—Place the decimal over its proper denominator; it is then a vulgar

gallons and bushels respectively in 80,000 inches, the operation will be as follows:—

By Division.		By Division.	
277·274) 80000·0000 (288·5	gallons.	2218·192) 80000·0000 (36·06	bushels.
554548		6654576	
2454520		13454240	
2218192		18309152	By Multiplicatn.
		000451	
2363280	By Multiplication.	14508800	80000
2218192	·003606	18309152	
	80000		36·080000
1450880		1199848	bushels
1386370	288·480000 gals.		

It is unnecessary to give further examples to show the manner in which factors are found, as this is sufficiently illustrated under the foregoing rule. To find a factor and to reduce a number to a decimal in reality involves the same process, and therefore all the decimals given as answers to the questions in pp. 27, 28, are factors to the given quantities.

Factors may be found for compound numbers or numbers of different qualities, by treating the additional number as a numerator to the fractional divisor instead of unity; thus, to find a factor for calculating a salary for any number of days at £50 per annum: the salary must be considered the numerator, and the number of days in a year the denominator, as $\frac{50}{365}$, which being reduced to a decimal by dividing the former by the latter will give ·136986 the factor required. This factor is simply the value of the salary for a single day, and when multiplied by any given number of days will show the amount of salary in pounds sterling.

The same result would be obtained by finding a factor for £1 by the former process and multiplying it by the number of pounds in the salary.

The valuable table in the Appendix, No. 24, is founded upon the foregoing principles. The factors for reducing solid inches into pounds weight of soap, and into gallons or bushels, and for reducing pence into pounds, &c., will be found in the table No. 30. See also the various tables of *decimals* (Nos. 2, 10, 12, 20, 22, 23, 24), which, for the reasons above stated, are in reality all tables of *factors*.

* EXAMPLES IN RULE IV.

(32.) Reduce ·5 to a vulgar fraction.

Place 5 the numerator, over 10 the denominator, thus $\frac{5}{10}$; it is then a vulgar fraction; and if we divide each of the numbers by 5, it will be reduced to its lowest term = $\frac{1}{2}$, Ans.

(33.) Reduce ·75 to a vulgar fraction.

$$\begin{array}{r} \frac{75}{100} \cdot 75 \text{) } 100 \text{ (} 1 \\ 75 \\ \hline \end{array}$$

$$\begin{array}{r} 25 \text{) } 75 \text{ (} 3 \\ 75 \\ \hline \end{array}$$

$$\begin{array}{r} 25 \text{) } 75 \text{ (} 3 \\ 25 \text{) } 100 \text{ (} 4 \text{ Ans.} \end{array}$$

The common divisor is found by dividing the denominator by the numerator and it again by the remainder, and so on, as directed in p. 22. The divisor to which there is no remainder is the common divisor.

(34.) Reduce 1·25 to a vulgar fraction. Ans. $1\frac{1}{4}$ or $1\frac{1}{2}$.

fraction, and may be reduced to its lowest terms, by dividing both terms by the largest number that will leave no remainder.

*V. To reduce a decimal to its proper denominations; that is, to find its denominational value.** Multiply the decimal by the value of the next lower denomination, and point off as many places to the right hand as there are places of decimals; then multiply the figures pointed off by the value of the next lower denomination, pointing off as before; and proceed in this manner through all the denominations, when the several figures standing on the left of the decimal point will be the answer required.

* EXAMPLES IN RULE V.

(35.) What is the value of $\cdot 05$ of a pound?

$$\begin{array}{r} \cdot 05 \\ 20 \\ \hline \text{Ans. 1s. } 1\cdot 00 \end{array}$$

(36.) What is the value of $\cdot 778125$ of a pound?

$$\begin{array}{r} \cdot 778125 \\ 20 \\ \hline 15\cdot 562500 \\ 12 \\ \hline \text{Ans. } 15s. 6\frac{1}{2}d. \\ 6\cdot 750000 \\ 4 \\ \hline 3\cdot 000000 \end{array}$$

Instead of multiplying by 20 and by 12, the value may be readily found as follows:—Divide the 2 first decimal figures by 5, and take the quotient for shillings; to the remainder annex the third decimal, rejecting 1 for every 25 contained in it, and divide by 4 for pence, the remainder is farthings: thus, in the preceding example, one-fifth of $\cdot 77$ is 15s. and 2 over; then 2 prefixed to 8, the next decimal, is 28, which, diminished by 1 and divided by 4, makes 6d. and $\frac{1}{2}$ over, the answer as above.

(37.) What is the value of $\cdot 1875$ of a pound? Ans. 3s. 9d.

(38.) What is the value of $\cdot 125$ of a shilling? Ans. $1\frac{1}{2}d$.

(39.) What is the value of $\cdot 40625$ of a quarter? Ans. 3 bushels and 1 peck.

(40.) What is the value of $\cdot 5625$ of a foot? Ans. $6\frac{3}{4}$ inches.

If the question includes a whole number as well as a decimal the operation extends only to the decimal; thus—

(41.) What is the value of 8·9453125 of 1 lb.?

$$\begin{array}{r} 8\cdot 9453125 \\ 16 \\ \hline 15\cdot 1250000 \\ 16 \\ \hline 2\cdot 0000000 \end{array} \quad \text{Ans. 8 lb. 15 oz. 2 dr.}$$

(42.) What is the value of 2·168 of a pound? Ans. £2 3s. $4\frac{1}{2}d$.

II. ADDITION AND SUBTRACTION.

In addition or subtraction of decimals,* care must be taken that the given numbers are arranged so that the decimal points may all be in the same column. The operation may then be performed in the same manner as in whole numbers; the decimal point of the answer being placed under the others.

III. MULTIPLICATION AND DIVISION.

These operations † are also performed with decimals in the same manner as with whole numbers; care being taken in

* EXAMPLES IN ADDITION AND SUBTRACTION.

(1.) Add together '47, '62, and '67; and (2.) 51'43, 90'02, and '076 respectively.	(3.) From 8'42 take 4'6; and (4.) from 1 take '954.		
$\begin{array}{r} .47 \\ .62 \\ .67 \\ \hline 1.76 \end{array}$	<table border="0"> <tr> <td>$\begin{array}{r} 8.42 \\ 4.6 \\ \hline 3.82 \end{array}$</td> <td>$\begin{array}{r} 1 \\ 0.954 \\ \hline 0.046 \end{array}$</td> </tr> </table>	$\begin{array}{r} 8.42 \\ 4.6 \\ \hline 3.82 \end{array}$	$\begin{array}{r} 1 \\ 0.954 \\ \hline 0.046 \end{array}$
$\begin{array}{r} 8.42 \\ 4.6 \\ \hline 3.82 \end{array}$	$\begin{array}{r} 1 \\ 0.954 \\ \hline 0.046 \end{array}$		
$\begin{array}{r} 51.43 \\ 90.02 \\ .076 \\ \hline 141.526 \end{array}$			

In subtraction, if there be no numbers above the lower, as in example (4.) the lower digit is subtracted from 10, and 1 carried to the next number.

In these questions it is assumed that the quantities have either been found in decimals or otherwise reduced to decimals, according to the foregoing rules, or by reference to the proper decimal tables in the Appendix. This, however, is seldom done in Addition where the calculations relate to money. The items are then usually cast up in their proper denominations, and in the common way; and the officer will find it as necessary to be expert in that kind of calculation as if decimals had not been invented. In particular he should endeavour to acquire facility in adding, by learning to sum up the columns by a glance of the eye without naming the numbers, and by adding two or more figures at once; especially where the sum of two or more figures is exactly 10, &c.

† EXAMPLES IN MULTIPLICATION AND DIVISION.

(1.) Multiply 670'41 by '05.	(2.) Divide 670'41 by '09.
$\begin{array}{r} 670.41 \\ .05 \\ \hline 33.5205 \end{array}$	$\begin{array}{r} .09 \overline{) 670.41} \\ \hline 7449 \end{array}$

Here the two factors together contain 4 decimal places; therefore 4 places of decimals are pointed off in the product.

Here the decimal places in the divisor and dividend are equal; consequently there is no decimal in the quotient.

multiplication to part off in the product as many places of decimals as there are in both factors, supplying the deficiency, when there is one, by prefixing ciphers; and in division pointing off in the quotient, when found, as many places of

(3.) Multiply $\cdot 2761$ by $\cdot 035$

$$\begin{array}{r} \cdot 2761 \\ \cdot 035 \\ \hline 13805 \\ 8283 \\ \hline \cdot 0096685 \end{array}$$

Here two ciphers are prefixed to the product to make the decimal places equal to those in the two factors.

(4.) Multiply $2\cdot 61045$ by $1\cdot 02345$.

$$\begin{array}{r} 2\cdot 61045 \\ 1\cdot 02345 \\ \hline 1305225 \\ 1044180 \\ 783135 \\ 522090 \\ 261045 \\ \hline 2\cdot 6716650525 \end{array}$$

Here the two factors together contain 10 places of decimals, which is the number pointed off in the product.

(5.) Divide $1500\cdot 4$ by $\cdot 929$, and (6.) $\cdot 0321$ by $16\cdot 5$.

$$\begin{array}{r} \cdot 929 \overline{) 1500\cdot 40000} \quad (1615\cdot 06 \\ 929 \\ \hline 5714 \quad 16\cdot 5 \cdot 0321000 \quad (\cdot 001945 \\ 5574 \quad 165 \\ \hline 1400 \quad 1560 \\ 929 \quad 1485 \\ \hline 4710 \quad 750 \\ 4645 \quad 660 \\ \hline 6500 \quad 900 \\ 5574 \quad 825 \\ \hline 926 \quad 75 \end{array}$$

In example (5.) it was necessary to use additional ciphers in the dividend, making the decimal places in the dividend 5; and as this number was found to exceed the number in the divisor by 2, two decimal places are pointed off in the quotient. In example (6.) the decimal places in the dividend, including the borrowed ciphers, are 7, and as the divisor only contained 1, and the quotient as first found, 4, it was necessary to prefix 2 ciphers to it, making up 6, the difference.

When the number of decimal figures is large, and great accuracy in the decimals not necessary, the operation may be materially shortened by the following approximative rules. In multiplication count off, after the decimal

$$\begin{array}{r} 2\cdot 61045 \\ 54320\cdot 1 \\ \hline 26105 \\ 522 \\ 78 \\ 10 \\ 1 \\ \hline 2\cdot 6716 \end{array}$$

point in the multiplicand, as many figures as you wish to have places of decimals in the product, adding ciphers, if necessary, to make up the required number. Reverse the multiplier, placing its first figure of whole numbers under the last place of decimals, counted off in the multiplicand. Multiply by each figure of the multiplier, beginning the multiplication by the figure which stands immediately above it, disregarding the other figures to the right in the multiplicand, except to find what is to be carried. Let all the partial products be so arranged, that their right hand figures may stand in the same column. Lastly, from the sum of these partial products point off the assigned number

decimals as the decimal places in the dividend exceed those in the divisor; or in other words to see that the divisor and

of decimal places. The example in the margin, which is the same as (4.) above, found to 4 decimals, will explain the mode of working, and show the great saving in figures effected by this rule.

In Division, instead of annexing ciphers or periodical figures to the dividend, cut off a figure from the divisor for each cipher or figure that would otherwise be added to the dividend, and increase each product by *carrying* from the product of the figure last cut off and the figure last placed in the quotient; as in the example in the margin, which is applicable to the foregoing example (5.)

$$\begin{array}{r}
 \cdot 929 \overline{) 1500 \cdot 4 (1615} \\
 \underline{929} \\
 5714 \\
 \underline{5574} \\
 140 \\
 \underline{93} \\
 47 \\
 \underline{46}
 \end{array}$$

When the question relates to quantities of different denominations, or includes a vulgar fraction, it will be necessary, before commencing the operation, to reduce them to decimals by the rules in p. 26, or by reference to the proper tables in the Appendix.

(7.) Multiply £50 15s. by 484.

(15s. = .75) $484 \times 50 \cdot 75 = 24563 \text{ £ Ans.}$

(8.) Multiply $58\frac{1}{2}$ gals. by 17000.

($\frac{1}{2} = \cdot 5$) $17000 \times 58 \cdot 5 = 994500 \text{ Ans.}$

(9.) Divide 24563 by £50 15s.

(15s. = .75) $24563 \div 50 \cdot 75 = 484 \text{ Ans.}$

(10.) Divide 994500 by $58\frac{1}{2}$ gals.

($\frac{1}{2} = \cdot 5$) $994500 \div 58 \cdot 5 = 17000 \text{ Ans.}$

There are, however, many cases in which it is more convenient to multiply and divide the mixed numbers without reducing them to decimals, especially where the multiplier or divisor consists of a single figure, or is the multiple of any two or more single figures. This is done by the common rules of arithmetic, as follows:—

(11.) What is the duty on 11 bushels of malt at 2s. 7d. per bushel?

$$\begin{array}{r}
 \text{£ } s. \text{ d.} \\
 0 \ 2 \ 7 \\
 \underline{11} \\
 \text{£1 } 8 \ 5 \text{ Ans.}
 \end{array}$$

(12.) What is the duty on 63 gals. of spirits at 7s. 10d. per gallon?

$$\begin{array}{r}
 \text{£ } s. \text{ d.} \\
 7 \times 9 = 63 \\
 0 \ 7 \ 10 \\
 \underline{7} \\
 2 \ 14 \ 10 \\
 \underline{9} \\
 \text{£24 } 13 \ 6 \text{ Ans.}
 \end{array}$$

(13.) Divide £1 8s. 5d. by 11.

$$\begin{array}{r}
 \text{£ } s. \text{ d.} \\
 11 \overline{) 1 \ 8 \ 5} \\
 \underline{2 \ 7} \text{ Ans.}
 \end{array}$$

(14.) Divide £24 13s. 6d. by 63.

$$\begin{array}{r}
 \text{£ } s. \text{ d.} \\
 7 \times 9 = 63 \quad 9 \overline{) 24 \ 13 \ 6} \\
 \underline{7} \quad \underline{2 \ 14 \ 10} \\
 \underline{7 \ 10} \text{ Ans.}
 \end{array}$$

For shortening the processes of multiplication and division, various methods have been suggested, the most scientific of which is a logarithmic table (Tab. 32), which is used in the following manner:—*To multiply*—Find the logarithms of the numbers and add them together; the number answering to this logarithmic sum is the product. *To divide*, subtract the logarithm of

quotient together contain as many places of decimals as there are in the dividend.

the divisor from that of the dividend; the number answering to the remainder is the quotient. Thus :

(15.) Multiply 37 by 26.

Log. of 37 = 1.568203

26 = 1.414973

log. 2.983175 = 962 Ans.

(16.) Divide 37 by 26.

Log. of 37 = 1.568203

26 = 1.414973

log. .153229 = 1.42 Ans.

The whole number placed before the logarithm is termed the index. It is not inserted in the table, as it can always be supplied by making it as many units, less 1, as there are places of figures in the corresponding number. Thus, the index of all numbers from 1 to 10, is 0; from 10 to 100, 1; and from 100 to 1000, 2. When the indices are added with the logarithms, as in the above example (15.), the sum of the indices (here 2) shows how many integers, plus 1, must be in the product of the given numbers, viz. 3. And so with division. In ex. (16.) there is 0 for index, therefore there is one place of whole numbers in the quotient. When the officer becomes acquainted with the mode of working by logarithms, the indices may be dispensed with, as they can be easily supplied by memory. Should the logarithm of any number not in the table be required, find the logarithm corresponding to the three first figures of the number; take the difference between it and the next greater logarithm, multiply the difference by the remaining figures, and from the product cut off as many figures as are in the multiplier; the rest, added to the logarithm for the first three figures, will give the logarithm required, nearly. And should a number be required, the logarithm of which is not in the table, subtract the next less logarithm from the given one, and also from the next greater in the table, and, annexing ciphers to the first remainder, divide it by the other, and affix the quotient to the number corresponding with the logarithm next less to the given one; to make the fourth, fifth, &c. places. The integer places must be one more than the units in the index, and the rest are decimals.

Other methods of shortening the operation of multiplication and division are as follows :—

To multiply by 5. Annex a cipher to the multiplicand, and take half the result.

To multiply by 25. Annex two ciphers to the multiplicand, and take one-fourth of the result.

To multiply by 125. Annex three ciphers to the multiplicand, and take one-eighth of the result.

To multiply by 75. Annex two ciphers to the multiplicand, and from the result take one-fourth of itself.

To divide by 5. Double the dividend, and cut off the last figure of the result.

To divide by 25. Multiply the dividend by 4, and cut off two figures from the result.

To divide by 125. Multiply the dividend by 8, and cut off three figures from the result.

To divide by 75. Multiply the dividend by 4, and divide the product by 300.

In dividing as above directed, it must be observed, that the true remainder in the first case is half the figure cut off; in the second, one-fourth of the two figures cut off; in the third, one-eighth of the three figures cut off; and in the fourth, one-fourth of the remainder found.

The foregoing rules will be found particularly useful in multiplying and dividing by decimals, as the numbers .5, .25, .125, and .75, are the decimals for the very common fractions of $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, and $\frac{3}{4}$ respectively.

Some useful abbreviations of the common rules of Multiplication and Division will be found in the notes.

To multiply by 15. Annex a cipher to the multiplicand, and to the result add half of itself. *To divide by 15, 35, 45, or 55.* Double the dividend, and divide the result by 30, 70, 90, or 110 respectively.

In these divisions, the true remainder is half the remainder found.

To multiply or divide by 10, 100, 1000, &c., it is only necessary to add a cipher or ciphers to the multiplicand, or to cut a figure or figures from the dividend.

When a multiplier or divisor is a multiple of two or three single figures, it is frequently convenient to perform the operation by using the figures that constitute the multiple separately, as in examples (12.) and (14.). The numbers constituting the multiples are called composite numbers, of which it is useful to have a table for reference.

If it be required to find the value of any number of articles corresponding with a number of a higher or lower denomination, the process of multiplying or dividing by that number may be saved by simply changing the name of the given number, thus :—

<i>To multiply</i>		<i>To divide</i>	
Farthings by	4, call them pence.	Pence by	4, call them farthings.
	48, call them shillings.	Shillings by	48, call them farthings.
	960, call them pounds.		12, call them pence.
Pence by	12, call them shillings.	Pounds by	960, call them farthings.
	240, call them pounds.		240, call them pence.
Shillings by	20, call them pounds.		30, call them shillings.

When the given price or rate of duty is any aliquot part, or even fraction or decimal of a penny, shilling, or pound, it is only necessary to divide the given quantity by such aliquot or even part, if a fraction, or to multiply it, if a decimal. Thus, to find the duty on 560 bushels of beer or bigg malt at 2s. per bushel, it is only necessary to divide the given number by 10 (2s. being $\frac{1}{10}$ of £1): thus, 10)560 (£56 Ans.: or to multiply it by .1 (.1 being the decimal of 2s. of £1): thus, $560 \times .1 = £56$ Ans. So, to find the duty on malt at 2s. 7d. per bushel, the given number may be divided by 8 (2s. 6d. being $\frac{1}{8}$ of £1), and the quotient by 30 (1d. being $\frac{1}{30}$ of 2s. 6d.), the sum of the two quotients is the answer; or the given number may be multiplied by .1292, the decimal of 2s. 7d. of £1. The duty on paper or soap may, in like manner, be calculated by dividing the given number by 8 ($1\frac{1}{2}$ being $\frac{1}{8}$ of 1s.), and by 20 to bring it to pounds. The aliquot parts and decimals for the above-named duties, and others, will be found in Table 22 in the Appendix. (See p. 28.)

When it is required to find the *per centage* of any given number, the process may be shortened by dividing such number by the aliquot part of 100. In the case of 5 per cent. (which is $\frac{1}{20}$ of 100, or 1s. in the pound), this is easily done by cutting off the units figure of the dividend, and dividing the remainder by 2, as in the following examples :—

(17.) What is the additional duty at 5 per cent. on 50 brewers' licences, amounting together to 140? 2,0)14,0 (£7 Ans.

(18.) What is the additional duty at 5 per cent. on malt duty amounting to £51 13s. 4d.? Ans. £2 11s. 8d.

In practice, the additional duty is obtained by taking $\frac{1}{20}$ of the original duty; the two amounts added together make the full duty. The only difficulty is in finding the per centage on sums and remainders falling under £1; but it is easily ascertained after a little practice, or may be obtained from Table 27 in the Appendix.

Per centages may also be calculated by multiplying the given sum by the rate,

IV. PROPORTION.*

Proportion is the equality of two ratios. A ratio is the mutual relation that magnitudes of the same kind bear to each other in respect of quantity. The equality of the ratio of two quantities to that of two other quantities is called *Simple Proportion*. The equality of the ratio of two quantities to another ratio, the products of the antecedents and consequents of two or more ratios, is called *Compound Proportion*. The object of that part of Simple Proportion which is applied to arithmetic, whether common or decimal, is to *find the fourth term of a proportion when the*

and cutting off two figures from the right, thus: (19.) Required, the duty or interest on £156 13s. 4d., at 5, 4½, 4, and 3 per cent. respectively.

£ s. d.	£ s. d.	£ s. d.	£ s. d.
156 13 4	156 13 4	156 13 4	156 13 4
5	4½	4	3
7,83 6 8	626 13 4	6,26 13 4	4,70 0 0
20	78 6 8	20	20
16,66	7,05 0 0	5,33	14,00
12	20	12	
8,00	1,00	4,00	

Ans., £7 16s. 8d.; £7 1s.; £6 5s. 4d.; and £4 14s.

It being so easy to find five per cent. by either of the foregoing means, this per centage is a convenient foundation for calculating other *per centages*. Thus, if it be required to find the amount of duty or interest at 7½ per cent., we may find the amount at 5 and add one half. For 4½ per cent., deduct ½. For 4 per cent., deduct ⅓. For 3½ per cent., deduct ⅓. For 3 per cent., deduct ⅓. And for 2½ per cent., take one half; &c. (See the Interest and Commission Tables, Nos. 26—29, and the Duty Tables, 51—55, in the Appendix).

But the most practically useful method of shortening these calculations is that of substituting multiplication for division, by means of what are technically termed "*factors*," such factors being the decimals or equivalents of the numbers which would otherwise be used as divisors. The mode of obtaining these factors is explained, and their great use exemplified, in p. 28, and a list of those most commonly required will be found in Table 30.

* Proportion is so universal in its application, at least, among all substances and qualities of substances which can any way be measured, weighed, or valued, so as to be expressible in numbers, that its importance cannot be too forcibly impressed on the student. In its various applications, it is the most useful in the whole business of education; and that not so much on account of its merely arithmetical and geometrical applications, as because, being founded upon the doctrine of cause and effect, no one can think or reason accurately upon any one subject without it.

*first three terms are given ; or, in other words, to find a fourth proportional to three given numbers.**

For arithmetical purposes, the question always assumes the shape of a proposition, thus : As one of the given numbers is to another of them, so is the third to the number sought. For example : If the three given numbers are 3, 5, and 12, and it be required to find a fourth number, which shall bear the same relation to the last as the second bears to the first, the proposition would be, as 3 is to 5, so

* A series of numbers is a succession of numbers which increases or decreases according to a certain law. When the series increases, by some constant number added to it, it is called *Arithmetical progression*. When it increases by the last number being always multiplied by a given number, it is called *Geometrical progression*. Thus, in the two following lines, the number 3 is continually added in one series, and used as a multiplier in the other.

5, 8, 11, 14, 17. Arithmetical progression.
5, 15, 45, 135, 405. Geometrical progression.

In each of these series, the numbers bear a certain proportion to each other and to the whole series. In the Geometrical series, for instance, the term 15 is proportionally greater than 5, as 45 is greater than 15, &c. In order to discover the *ratio* between any two terms of a geometrical series, we divide the greater by the less, and the quotient is the *ratio*; thus, 45 divided by 15 gives 3 as the *ratio*. By thus ascertaining the *ratio*, we are furnished with the means of arriving at the *ratio* of the other terms in the series. Suppose, for instance, we have three terms of the above series given, and it be desired to find a fourth term bearing the same proportion to the third as the second bears to the first, we have only to ascertain the *ratio* between the two first terms by dividing the one by the other, and this gives the ratio 3, with which, by multiplying the third term, we produce the fourth. The same result is obtained, if, according to the rule in the text, we multiply the second and third terms together, and divide by the first. And this formula is as applicable for finding a second term of any series in the same ratio, as it is for finding the third term in the same series. Thus, if we have only two numbers of the foregoing series, 5 and 15, and another of a different series, say 6, and it be desired to find what term bears the same proportion to 6, as 15 does to 5, here the answer will evidently be 5 : 15 :: 6 : 18. Euclid, in his fifth book, has proved that whatever operation is performed on the first and second of such terms, a similar operation on the two last will preserve the proportion. Thus, in the proposition just

Given	5 : 15 :: 6 : 18
By inverting the terms	15 : 5 :: 18 : 6
By changing	5 : 6 :: 15 : 18
By composition	(5 + 15) 20 : 15 :: (6 + 18) 24 : 18
	(5 + 15) 20 : 5 :: (6 + 18) 24 : 6
By division or difference {	(15 - 5) 10 : 5 :: (18 - 6) 12 : 6
	(15 - 5) 10 : 15 :: (18 - 6) 12 : 18

The proportion will be equally preserved, if we multiply the first and second or first and third terms respectively by any other number, and take the products in either case for two of the terms of the proportion,

is 12 to the number sought, viz. 20 ; written with signs or abbreviations, thus, $3 : 5 :: 12 : 20$.

*The rule for finding the fourth term is the same in all cases, whether the question relates to whole or mixed numbers or to decimals, and is as follows:—Multiply the second and third terms together, and divide the product by the first ; the quotient is the answer.**

* This rule was formerly called the "Rule of Three," because, in each of its questions, at least three numbers are given ; and from its extensive use it obtained the appellation of the "Golden Rule." When the Rule is understood, the operation is easily performed ; the chief difficulty is, as to the manner in which the various questions are to be stated for working. To obviate this difficulty as far as practicable, consistently with the limits and object of the present Treatise, a few of the leading subjects to which Arithmetical Proportion is usually applied in excise calculations are selected, the examples being such as are most likely to form the subject of examination for promotion ; and being in each case preceded by the proposition, and mode of stating the question. One of the most simple and useful applications of the Rule is the following :—

PRICES, DUTIES, SALARIES, AND INTEREST.

I. To find the duty or value of an article when two quantities of the same kind of goods are given, with the rate of duty or price upon one of them.—As the quantity of which the duty or price is known is to the quantity on which it is sought, so is the known duty or price to the duty or price required.

(1.) If a soapmaker's license be £4, (2.) If 69 soapmakers' licenses what will be the amount of 69 such licenses? amount to £276, what is that per license?

$$\begin{array}{rcl} \text{l.} & \text{l.} & \text{£} \\ \text{As } 1 & : & 69 :: 4 \end{array}$$

$$\begin{array}{rcl} \text{l.} & \text{l.} & \text{£} \\ \text{As } 69 & : & 1 :: 276 \end{array}$$

$$\begin{array}{r} 4 \\ \hline 1) 276 \end{array} \quad \begin{array}{r} \text{£} \\ 4 \end{array} \quad \text{Ans.}$$

$$\begin{array}{r} 1 \\ \hline 69) 276 \end{array} \quad \begin{array}{r} \text{£} \\ 4 \end{array} \quad \text{Ans.}$$

If the first or second term be a mixed or broken number, it is necessary, before commencing the operation, to bring the two first terms into the lowest denomination of the two ; or to reduce the mixed number to its equivalent decimal. And as the answer will always be in the same denomination as that in which the third number was left, this latter number should be brought into the denomination most convenient for working before it is multiplied by the second term. The answer, when obtained, may be reduced to the usual denomination by the proper rule.

(3.) If the duty on hard soap be 1½d. per lb., what is that per cwt.?

$$\begin{array}{rcl} \text{lb.} & \text{lb.} & \text{d.} \\ 1 & : & 112 :: 1\frac{1}{2} : \end{array}$$

$$\begin{array}{r} 6 \\ \hline 4) 672 \end{array} \quad \begin{array}{r} \text{d.} \\ 6 \end{array}$$

$$12) 168$$

14s. Ans.

(4.) If the duty on 1 cwt. of soap be 14s., what is that per lb.?

$$\begin{array}{rcl} \text{lb.} & \text{lb.} & \text{s.} \\ 112 & : & 1 :: 14 \end{array}$$

$$\begin{array}{r} 14 \\ \hline 112) 168 \end{array} \quad \begin{array}{r} \text{s.} \\ 1\frac{1}{2} \end{array} \quad \text{Ans.}$$

$$112$$

$$56$$

$$4$$

$$112) 224 \quad (2)$$

In stating the proposition it should be considered whether the required or fourth term is to be greater or less

(5.) If the duty on a gallon of Scotch spirits be 3s. 8d., what is that on 960 gallons?

$$\begin{array}{rcl} \text{g.} & \text{g.} & \text{£} \\ 1 & : & 960 :: '18333' (= 3s. 8d.) \\ & & 18333 \end{array}$$

175·99680 = £176 very nearly.

(7.) If an officiator's salary be 5s. 5½d. per day, what is that per year?

$$\begin{array}{rcl} \text{d.} & \text{d.} & \text{s. d.} \\ 1 & : & 365 :: 5 \frac{1}{2} : 100 \text{ Ans.} \end{array}$$

(9.) What is the duty on 31 of a bushel of malt at 2s. 7d. per bushel, with 5 per cent. additional = 32·55d.?

Ans. 10·0905d.

(6.) If the duty on 960 gallons of Scotch spirits be £176, what is that per gallon?

$$\begin{array}{rcl} \text{g.} & \text{g.} & \text{£} \\ 960 & : & 1 :: 176 \\ & & 1 \end{array}$$

960) 176 ('18333' = 3s. 8d. Ans.

(8.) If an officiator's salary be £100 per annum, what is that per day?

$$\begin{array}{rcl} \text{d.} & \text{d.} & \text{£} \\ 365 & : & 1 :: 100 : 5 \frac{1}{2} \text{ Ans.} \end{array}$$

(10.) The duty on malt in the year 1850 was £5,645,490; how many net bushels were charged?

Ans. 41,625,782 bushels.

It will be observed, that, when the first term is unity, the answer is obtained by multiplication alone; and when the second or third term is unity, the answer is obtained by division alone. And in these cases the formality of stating the question is usually dispensed with (see p. 34). The foregoing examples are given to show the principle on which the operations depend.

(11.) The duty on 12½ bushels of malt (including the additional 5 per cent.) is £1 13s. 10½d. (more nearly, £1 13s. 10·875d.); what is the duty on 300 bushels?

$$25 (= 12\frac{1}{2} \times 2) : 600 (= 300 \times 2) :: 1627 (= £1 \ 13s. \ 10\frac{1}{2}d.) : £40 \ 13s. \ 6d. \text{ Ans.}$$

Or, 12·5 : 300 :: 408·875 : £40 13s. 9d. Ans.

(12.) If 1¼ bushels of malt produce 2 gallons of spirits, what will 750 bushels produce? Ans. 1161¾.

(13.) If 1 cwt. of sugar costs 14s., and produces 11 gallons of spirits, the drawback on which is 12s. 10½d., what drawback will there be upon 11 gallons when sugar is at 13s. per cwt. Ans. 11s. 11½d.

(14.) At a cleanse of soap the gauge amounted to 22,261 lbs., and a pound was 25 cubic inches; but on weighing, it was found to be 24,360 lbs. Required the cubic inches in a pound proportioned to the latter quantity?

$$24360 : 22261 :: 25 : 22·84 \text{ Ans.}$$

(15.) What is the amount of an officiator's salary for 66 days, at £50 per annum? 365 : 66 :: 50 : £9 0s. 9½d. Ans.

This and similar questions of common occurrence may frequently be solved more readily by finding a factor for a single day or a single article, and multiplying such factor by the number of days or articles. In the foregoing question, the factor for a single day is found (see p. 30), and used as follows: 365 : 1 :: 50 : '1369663'. Then '1369663' × 66 = 9·0410958 = £9 0s. 9½d., as before.

For a leap-year the decimal for a single day is slightly varied. Thus, 366 : 1 :: 50 : '136612'. (See Table 24 for calculating salaries.)

If the amount per day is known, a ready method of finding the yearly salary is the following:—Take as many pounds, half-pounds, and fipences, as there are pence in the salary per day, the sum is the amount per annum. If Sundays are not included, as many pounds, crowns, shillings, and pence, as there are pence per day, will give the yearly salary.

To find the number of days between one month and another, refer to

than the third ; if greater, the greater of the other two terms should be put in the second place ; if less, in the first.

Table 4 ; and observe, that, if both days are inclusive, one day must be added ; and that, if it be a leap-year, and February be included, a day must also be added.

(16.) What is the interest of £547 15s. for a year at 5 per cent.?

$100 : 5 :: 547.75 (=£547\ 15s.) : 27.3875 = £27\ 7s.\ 9d.$ Ans.

A shorter mode of calculating amounts connected with *per centage* will be found in p. 37.

If the interest be required for any number of years, the answer, found as above, must be multiplied by the years required.

It may save time in these calculations to recollect that the interest at 5 per cent. is 1s. per year, or 1d. per month, for every pound in the principal.

PER CENTAGES.

II. To ascertain the increase or decrease per cent. on any article or value.

—As the price or value, diminished or increased by the given rate or value, is to such rate or value, so is 100 to the per centage increased or diminished.

(17.) How much per cent. is the price of malt enhanced by the duty, when it sells at 8s. 6d. per bushel?

8s. 6d. = 102d.

Duty = 32.55

$\frac{69.45}{100} : 32.55 :: 100 : 46.86$ per cent. Ans.

It will be observed, that, in this and similar cases, it is necessary, before stating the question, to deduct the duty or rate from the price or value.

(18.) If 1 quarter of malt cost 60s., the duty on which is £1 0s. 8d. and 5 per cent ; how much per cent. is the price increased by the duty? Ans. 56.65.

(19.) If 1 lb. of hard soap cost 6d., how much per cent. does the duty (= 1.575d. per lb.) affect the price? Ans. £35 11s. 10½d.

(20.) If a ream of paper weighing 14 lbs. sells for 10s., how much per cent. does the duty (= 1.575d. per lb.) enhance the price? Ans. 22.51.

(21.) If the duty be taken off paper, how much per cent. would it be cheaper per ream of 14 lbs. now costing 10s?

$120d. : 22.05 (= 1.575 \times 14) :: 100 : 18.37$ per cent. Ans.

(22.) The first gauge of a maltster's cistern amounted to 118.6 bushels ; the second to 129.9 ; required the rate per cent. of increase?

$118.6 : 11.3 (= 129.9 - 118.6) :: 100 : 9.52$ per cent. Ans.

(23.) If the greatest swell upon a maltster's cistern or couch amounted to 22.7 per cent, what per cent. is that on the dry barley?

$122.7 (= 100 + 22.7) : 22.7 :: 100 : 18.50$ per cent. Ans.

(24.) The couch bushels found at nine hours after emptying, being 88.8, thrown out and returned were found to be 96.1 ; how much per cent. is this over or under what the law allows?

$88.8 : 7.3 (= 96.1 - 88.8) :: 100 : 8.2$ per cent. Then $8.2 - 6$ (= the allowance by law for nine hours) = 2.2 illegal increase.

(25.) If the allowance of the greatest quantity of grain found is 18½ per cent., what is the increase per cent. on the dry barley wetted?

$81.5 (= 100 - 18.5) : 18.5 :: 100 : 22.69$ per cent. Ans.

(26.) If the allowance for the swell of the grain in the cistern and couch be 22.69 per cent., what would 81.5 bushels of dry barley produce?

$100 : 122.69 (= 100 + 22.69) :: 81.5 : 99.99$ bushels. Ans.

(27.) If the allowance for the swell of the grain in the cistern and couch be 22.69 per cent., what is the allowance on 81.5 bushels?

$100 : 22.69 :: 81.5 : 18.49$ Ans.

When numbers of different qualities are given, the term which is of the same kind with the required term should be placed the third in order.

(28.) At a cleanse of soap the gauge amounted to 22,261 lbs.—but on weighing, it was found to be 24,360 lbs.; what is the increase per cent?

$$22,261 : 2,099 (=24,360-22,261) :: 100 : 9.42 \text{ Ans.}$$

SPECIFIC GRAVITIES.

III. *To determine the specific gravity of a solid on its being weighed in and out of water.*—As the lost weight in is to the weight out, so is the specific gravity of water to that of the body.

(29.) Required the specific gravity of a quantity of soap weighing 30 lbs. in air, and .635 lbs. in water?

$$\text{lbs. lbs. oz. oz.}$$

30—.635 = 29.365 Then, as 29.365 : 30 :: 1000 (water) : 1021 sp. gr. Ans.

(30.) A sample of soap weighs, in air, 240.6 grains, and in water, at 62°, 14.05 grains; what is the specific gravity? Ans. 1.062.

IV. *To determine the specific gravity of a fluid by weighing a solid body in it.*—As the whole or absolute weight of the solid body is to the loss of weight when weighed in the given fluid, so is the specific gravity of the solid to the specific gravity of the fluid.

(31.) A piece of cast iron (the specific gravity of which is 7.645) weighs, in a certain fluid, 265.925 ounces, and 298.1 ounces out of it; required the specific gravity of the fluid?

$298.1 - 265.925 = 32.175$, the loss of weight in the iron; then $298.1 : 32.175 :: 7.645 : .825$, the specific gravity of the fluid, showing it to be equal to alcohol.

In practice, the specific gravity of spirits is found by Sykes's Hydrometer, and the gravity or density of distillers' worts by Bates's Saccharometer. (See CHEMISTRY, and Table 19.)

V. *To find the weight of a body from its magnitude and specific gravity.*—As 1728 cubic inches (= 1 foot) is to the content of the body in cubic inches, so is the specific gravity to the weight of the body in ounces avoirdupois.

(32.) Required the weight of a gallon of proof spirits at the temperature of 51°, its specific gravity being .823?

$$1728 : 277.274 :: 923 : 148.104 \text{ oz.} = 9 \text{ lb. } 4 \text{ oz. } 1 \text{ dr. Ans.}$$

In practice, these calculations are made upon the assumption that 1 gallon of water weighs 10 pounds, which, although it does not give a perfectly accurate result (see p. 24), forms convenient data for the operations; as it is only necessary, in effect, to multiply the specific gravity by 10, or, in other words, to remove the decimal point one place farther back; the result gives the weight in pounds. The formula in the above example would thus be—

$$1 : .923 :: 10 : 9.23 \text{ lbs.} = 9 \text{ lbs. } 3 \text{ oz. } 10 \text{ dr.}$$

If the question applies to more than 1 gallon, either the third number or the result must be multiplied by the number of gallons given. Upon this principle Tables are made showing the weight of spirits at different strengths and temperatures, calculated upon their respective specific gravities, and which are indispensable when spirits are computed by weight. (See *Long's Tables of Weights and Specific Gravities*; and Table 19 in the Appendix.)

(33.) Required the weight of 25 gallons of spirits at 25 per cent. o. p. at the temperature of 60°, the specific gravity being .8869?

$$\text{Ans. by the second method, } 221 \text{ lbs. } 11 \text{ oz. } 10 \text{ drs.}$$

(34.) Required the weight of a piece of soap measuring 27.93 cubic inches, its specific gravity being .990? $1728 : 27.93 :: 990 : 16 \text{ oz.} = 1 \text{ lb.}$ Ans.

If more than three numbers are given, the question is considered to be *Compound or Double Proportion*, and may

In practice it is usual to assume that 27·7274 cubic inches are equal to 1 lb. of water, and to multiply the cubic inches in the body by the specific gravity, and divide by 27·7274; thus:

$$27\cdot7274 : 27\cdot93 :: \cdot990 : \cdot9972 \text{ lb.} = 15 \text{ oz. } 15 \text{ dr.}$$

(35.) If the specific gravity of soap be ·990, what is the weight of a piece 40 inches long, 15 wide, and 12 thick?

Ans. By the first method, 257 lbs. 13 oz.; and by the second, 257 lbs. 1 oz.

Instead of these operations, the specific gravity may be multiplied by the proper factor, ·03616898148, or ·03608, according to the standard adopted (p. 24); the product is the weight of 1 inch in pounds avoirdupois; which, being multiplied by the number of inches in the body, gives the total weight in pounds, as above.

(36.) Required the weight of 73 gallons of port wine, its specific gravity being ·997? Ans. 729 lbs. 14 oz.

VI. To find the magnitude of a body from its weight and specific gravity.—As the specific gravity of a body is to its weight in ounces, so is 1728 cubic inches (=1 foot), to its magnitude in inches.

(37.) Required the content of a quantity of proof spirits weighing 148·104 oz. at the temperature of 51°, its specific gravity being ·923?

$$923 : 148\cdot104 :: 1728 : 277\cdot274 \text{ inches} = 1 \text{ gallon.}$$

In practice these calculations are made upon the assumption that 1 gallon of water weighs 10 lbs. which makes it only necessary to divide the weight in pounds by the specific gravity, and to remove the decimal point in the quotient forward one place for gallons, which is the same as dividing the quotient by 10 (=the number of pounds in a gallon, p 42). Thus:

$$\cdot923 : 1 :: 9\cdot25 \text{ lbs.} (=148\cdot104 \text{ oz.}) : 10\cdot0216 \div 10 = 1\cdot00216 \text{ gals.}$$

(38.) Required the content of a piece of soap weighing 16 oz., its specific gravity being ·990?

$$990 : 16 :: 1728 : 27\cdot93 \text{ cubic inches. Ans.}$$

In practice it is usual to divide 27·7274, the number of inches in 1 lb. by the specific gravity; the quotient gives the number of cubic inches in 1 lb. of the body, somewhat higher in amount than as above.

(39.) Required the content in cubic inches of an empty cask made of dry oak, the specific gravity being ·925 and the weight 46 lbs. 10 oz.?

$$925 \text{ oz.} : 746 \text{ oz.} (=46 \text{ lbs. } 10 \text{ oz.}) :: 1728 \text{ in.} : 1393\cdot6 \text{ in. Ans.}$$

VII. To find the specific gravity of a body from its weight and magnitude.—As the content of the body in cubic inches is to 1728 (=1 foot), so is its weight in ounces to its specific gravity.

(40.) Required the specific gravity of a gallon of proof spirits at the temperature of 51°, its weight being 148·104 oz.?

$$277\cdot274 : 1728 :: 148\cdot104 : 923 \text{ sp. gr. or proof. Ans.}$$

If the calculation be made upon the assumption that 1 gallon of water weighs 10 lbs., the answer will be obtained by removing the decimal point in the pounds of the body one place forward; thus:

$$10 \text{ lbs.} : 9\cdot256 \text{ lbs.} (=148\cdot104 \text{ oz.}) :: 1 : \cdot925.$$

(41.) Required the specific gravity of 25 gallons of spirits at 25 per cent. a.p., at the temperature of 60°, the weight being 221 lbs. 11 oz. 10 drs.?

$$\text{Ans. by the second method, } \cdot8869.$$

If the question refers to more than 1 gallon, either multiply the first term or divide the fourth by the number of gallons given.

(42.) Required the specific gravity of 1 lb. of soap, measuring 27·93 cubic inches?

$$27\cdot93 : 1728 :: 16 : 990$$

be solved in the following manner. Place the term which is of the same kind as the required term in the last place.

In practice, when the question refers to a single pound, it is usual to divide 27·7274 by the cubic inches, which gives rather a higher result than as above; thus : $27\cdot93 : 27\cdot7274 :: 1 : \cdot992$ *sp. gr.* Ans.

REDUCING, AVERAGING, AND COMPOUNDING SPIRITS AND WORTS.

VIII. *To ascertain what quantity of spirits at proof are contained in a given quantity under or above proof; or, in other words, to reduce spirits to proof.*—As 100 is to the given strength (found by adding or deducting the number of degrees above or below proof to or from 100), so is the quantity given to the quantity at proof.

(43.) Reduce 40 gallons of spirits at 30 per cent. over proof to proof.

$$100 + 30 = 130$$

$$100 : 130 :: 40 : 52 \text{ gallons at proof.}$$

(44.) Reduce 25½ gallons at 32 per cent. under proof to proof.

$$100 - 32 = 68$$

$$100 : 68 :: 25\cdot5 : 17\cdot34 \text{ gallons at proof.}$$

The same result will be obtained if we multiply the quantity by the excess or deficiency over or under proof, and divide by 100; then add the quotient to the quantity if over proof, and subtract it if under proof; the sum or difference will be the answer. Thus, in the foregoing examples :

$$(40 \times 30) \div 100 = 12; \text{ and } 40 + 12 = 52 \text{ Ans.}$$

$$(32 \times 25\cdot5) \div 100 = 8\cdot16; \text{ and } 25\cdot5 - 8\cdot16 = 17\cdot34 \text{ gals. Ans.}$$

IX. *To reduce spirits from any given strength to any higher or lower strength.*

—As the required strength is to unity, so is the product of the given quantity and the given strength to the quantity at the strength required.

(45.) Reduce 40 gallons at proof to 30 per cent. under proof.

$$100 - 30 = 70 \quad 40 (\text{given quantity}) \times 100 (\text{given strength}) = 4000. \text{ Then,}$$

$$\text{As } 70 : 1 :: 4000 : 57\cdot14 \text{ gals. at 30 per cent. under proof.}$$

If it be desired to ascertain what quantity of water must be added to a given quantity of spirits at proof to reduce the same to a given strength under proof; deduct the given quantity of spirits from the quantity (found as above) at the strength required; the difference will be the answer. Thus, in the foregoing example, if 40 be deducted from 57·14, the difference (17·14) shows the quantity of water necessary for reducing it from one strength to another. (See Table 42.)

(46.) Bring 20 gallons of spirits at 20 *o.p.* to 25 *u.p.* Ans. 32 gals.

If more than 32 gallons had been found the excess would be seizable. Thus :

(47.) If 100 gallons at 5·5 *o.p.* be reduced to 132·5 at 14·0 *u.p.*; how much must be seized at 14·0 *u.p.* to which it was reduced? Ans. 9·9 gals.

(48.) Reduce 32 gallons of spirits at 25 per cent. *u.p.* to 20 per cent. *o.p.*

$$100 + 20 = 120 \quad 32 \times 75 = 2400$$

$$120 : 1 :: 2400 : 20 \text{ gallons at 20 per cent. over proof.}$$

Spirits, however, cannot practically be reduced from a lower to a higher strength without increasing the quantity.

X. *To reduce spirits from one strength to another by the use of other spirits.*—As the greater difference between the strength required and the two given strengths is to the lesser, so is the quantity given to the quantity required.

(49.) How much spirits at 47 per cent. over proof must be added to 54 gallons at 17·4 per cent. under proof to raise it to 16 per cent. under proof?

The difference between (16 *u.p.*) 84 and (47 *o.p.*) 147 is 63; and the difference between (17·4 *u.p.*) 82·6 and (16 *u.p.*) 84 is 1·4. Then,

$$\text{As } 63 (\text{greater diff.}) : 1\cdot4 (\text{lesser diff.}) :: 54 : 1\cdot2 \text{ gallons. Ans.}$$

Comparing the other given terms by pairs of the same denomination, place each term in the first or second place,

(50.) How much spirits at 15 per cent. under proof must be added to 40 gallons at 50 per cent. under proof to raise it to 25 per cent. under proof?

$$75 - 50 = 25; \text{ and } 85 - 75 = 10$$

$$25 : 10 :: 40 : 16 \text{ gals. Ans.}$$

(51.) How much spirits at 25 per cent. under proof must be added to 30 gallons at proof, to reduce it to 10 per cent. under proof?

$$90 - 75 = 15 \quad \text{And } 100 - 90 = 10$$

$$15 : 10 :: 30 : 20 \text{ gals. Ans.}$$

See Tables 42, 43, 44.

XI. *To find the relative quantity of spirits and water in a compound of a given value.*—As the given value of the spirits is to the whole mass, so is the value of the mixture to the quantity, which, deducted from the whole mass, will leave the quantity of water.

XII. *To reduce worts from one gravity to another by the addition of water.*—As the required gravity is to the gravity given; so is the given quantity to the quantity at the required gravity.

(52.) If 8760 gallons of worts at 67° be reduced to 56° by the addition of water, how many gallons will there be in the mixture, and how much water is required?

$$50 : 67 :: 8760 : 11738 \text{ gals. at } 50^\circ$$

$$\text{Then, } 11738 - 8760 = 2978 \text{ gals. of water required.}$$

XIII. *To find the gravity of wort added to worts of a given gravity, the quantities and gravities of the compound being given.*—As the difference between the two quantities is to the difference between the values (each quantity being multiplied by its respective gravity), so is unity to the gravity required.

(53.) If 1760 gallons of wort at the gravity of 52° be increased to 2000 gallons at 65°, what is the gravity of the wort added?

$$2000 \times 65 = 130,000$$

$$1760 \times 52 = 91,520$$

$$240 : 38,480 :: 1 : 160. \text{ Ans.}$$

(54.) Suppose 500 gallons of wash in a wash-back, the declaration and gravity 48°; on a second visit you find 580 gallons in the same back, gravity 52°; what is the gravity of the wort added? Ans. 77°.

XIV. *To find the strength or value of a compound, the rates and quantities of the ingredients being given.*—As the whole composition is to its total value or strength (each quantity being multiplied by its price or strength), so is any part of the composition to the mean price or strength of that part.

(55.) 25 gallons of spirits, at 16 per cent. under proof, are mixed with 15 gallons of proof spirits; what strength will the compound be?

quan. strength.

$$25 \times 84 = 2100$$

$$15 \times 100 = 1500$$

$$\frac{40}{48} \quad \frac{3600}{}$$

$$40 : 3600 :: 1 : 90 = 10 \text{ per cent. u. p. Ans.}$$

(56.) If 500 gallons of worts at 57° gravity, and 350 gallons at 44° be mixed, what is the gravity of the mixture?

$$500 \times 57 = 28,500$$

$$350 \times 44 = 15,400$$

$$\frac{850}{43,900} : 1 : 51.64^\circ \text{ gravity.}$$

(57.) If a wash-back contain 12,765 gallons of wash, at the gravity of 4°, and 466 gallons of water be added thereto, what will be its gravity?

$$\text{Ans. } 3.86.$$

as in Simple Proportion. Divide the continual product of the second terms and the last by the continual product of the first terms; the quotient will be the answer.*

V. EVOLUTION.

The root of any given number or power is such a number as being multiplied by itself a certain number of times will

(58.) 53 gallons of spirits, at 10s. per gallon, being mixed with 15 gallons of water, what is the value of a gallon of the mixture?

$$(53 + 15 =) 68 : (53 \times 10 =) 530 :: 1 : 7s. 9\frac{1}{2}d. \text{ Ans.}$$

XV. To find the value of spirits according to the strength, or the strength according to the value.—As the given strength is to any other strength, so is the given price to the price required at that strength, and *vice versa*.

(59.) Spirits at proof are worth 32s. per gallon; what would be their value at 25 per cent. o. p.? $100 : 125 :: 32 : 40s. \text{ Ans.}$

(60.) Spirits at 25 per cent. o. p. are worth 20s. per gallon; what would be their value at 10 per cent u. p.? $\text{Ans. } 14s. 4\frac{1}{2}d.$

(61.) Spirits at 25 per cent. o. p. are worth 40s. per gallon; what strength ought they to be at 32s. per gallon? Ans. proof.

XVI. To find the quantity of water necessary for reducing spirits to a given value.—As the value of the reduced mixture is to the price of the spirits, so is the given quantity to the whole reduced mixture; from which if the spirits be deducted, it will leave the quantity of water required.

(62.) 53 gallons of spirits at 10s. per gallon are required to be reduced until they are worth 8s.; what quantity of water is necessary?

$$8 : 10 :: 53 : 66\frac{1}{2}; \text{ then } 66\frac{1}{2} - 53 = 13\frac{1}{2} \text{ gallons water. Ans.}$$

* EXAMPLE OF COMPOUND PROPORTION.

(63.) What is the interest of £456 10s. for 31 days at 5 per cent.?

$$\begin{array}{rcl} 365 \text{ days} & : & 31 \text{ days} \\ 100\% & : & 456\text{ } 5\text{ } 10 \end{array}$$

$$36,500 \quad : \quad 14,151\text{ } 5 :: 5\% : \text{£}1 \text{ } 18 \text{ } 9\frac{1}{2}d. \text{ Ans.}$$

When the interest is for days, it is obvious from the preceding example, that 36,500 will always be the divisor. A more simple divisor, however, may be obtained by doubling the rate and the first term, and then the question may be solved without a statement; thus, multiply the principal by the days and by twice the rate, and divide the product by 73,000 = (36,500 × 2), the quotient will be the answer; thus:

$$456\text{ } 5 \times 31 (=14,151\text{ } 5) \times 10 = 141,515 \div 73,000 = \text{£}1 \text{ } 18s. \text{ } 9\frac{1}{2}d. \text{ Ans.}$$

Or the answer may be obtained still more readily by finding and using a factor for the constant divisor 36,500 = .0000274 (see pp. 30, 40); thus:

$$456\text{ } 5 \times 31 (=14,151\text{ } 5) \times 5 = 70,757\text{ } 5; \text{ and } 70,757\text{ } 5 \times \text{'0000274} = \text{£}1 \text{ } 18s. \text{ } 9\frac{1}{2}d. \text{ Ans.}$$

If the principal be multiplied by double the rate, which is the most convenient mode for 5, 50, or 5 (=ten shillings) per cent., the factor is .0000137, one half of the former factor.

(64.) If in 1 quarter (=8 bushels) of the materials used in the distillation of 20 gallons of spirits, $\frac{1}{4}$ of said materials be charged with the malt duty, how much of the malt duty attaches to each gallon?

$$\begin{array}{rcl} 1 \text{ gal.} & : & 8 \text{ gals.} \\ 20 & : & 1 \text{ } \\ 11 & : & 1 \text{ } \\ \hline & & d. \quad d. \\ 220 & : & 8 :: 32\text{ } 55 : 1\text{ } 183. \text{ Ans.} \end{array}$$

produce such given number or power ; the square of any number is gained by multiplying the number by itself ; the cube by multiplying the square by the number ; the biquadratic or fourth power by multiplying the cube by the number, and so of any other power.* To extract the square root of a number, therefore, is to find a number, which, multiplied by itself, will produce the number proposed. To extract the cube root of any number is to find a number, which, multiplied by itself, and that product again by itself, will produce the proposed number.

To extract the square root.†—Begin at the unit figure of

* The squares, cubes, and fourth powers of different numbers as far as 10 are as follows :—

Root, or 1st power .	1	2	3	4	5	6	7	8	9	10
Square, or 2nd power	1	4	9	16	25	36	49	64	81	100
Cube, or 3rd power .	1	8	27	64	125	216	343	512	729	1000
Biquad. or 4th power	1	16	81	256	625	1296	2401	4096	6561	10,000

The powers of numbers are usually expressed by adding a small figure to them. Thus, 3^2 signifies a square or second power of 3, that is, $3 \times 3 = 9$; 3^3 signifies the cube or third power of 3, that is, $3 \times 3 \times 3 = 27$, &c. The process of squaring or cubing any number, that is, *Involution*, is easily performed by multiplication ; but the converse, namely, *Evolution*, involves longer and more difficult operations, for which the sliding-rule or a logarithmic table is a useful substitute. (See p. 60, and Table 32.)

† The square root of many small quantities may easily be ascertained by means of the multiplication table. For instance, 6 is at once seen to be the square root of 36, because $6 \times 6 = 36$; but when larger and uneven numbers occur, it is necessary to have recourse to the process described in the text. Supposing, for instance, it were required to extract the square root of 59,049, or, which is the same thing, to find the length of the side of a square which contains 59,049 square inches; it is evident, that it cannot at once occur to the mind what number, by being multiplied into itself, produces this quantity. It is, therefore, requisite to find the square of one part of the number, and then the square of the other part. To effect this, the whole number is divided into periods of two figures each, which is done, because the square of a single figure never consists of more than two places, and the square of a number of two figures of not more than four places, &c. In the given example, the number is divided into three periods by placing a separating mark between 5 and 9 and 0 and 4: then 5, being the first period, 2 as being the root of 4, the nearest square to 5, is placed in the quotient, and the square of 2 ($2 \times 2 = 4$) is subtracted from 5. The next period 90 is then annexed to the remainder for a new dividend; the root (2) is doubled for a divisor; and after ascertaining how often it is contained in the dividend, omitting the last figure, the result (4) is placed both in the quotient and in the unit's place of the divisor; the whole number (44) is multiplied by 4, and the product subtracted from the dividend. The same process is repeated for the next

$$\begin{array}{r}
 5'90'49 \text{ (243)} \\
 4 \\
 \hline
 44) 190 \\
 176 \\
 \hline
 483) 1449 \\
 1449 \\
 \hline
 0
 \end{array}$$

whole numbers, and cut off, as often as possible, periods of two figures each, and if there are decimals cut them off in

period, which gives 3 as its root, and as there is no remainder, the three figures 243 constitute the square root sought.

Again if it be required to find the square root of 12345·6789, the integers are divided into three periods, and the decimals into two; but as it is necessary for continuing the work to three places of decimals to add two ciphers, the given decimals may be considered as divided into three periods. The result of this operation on the first nine units is curious, the root being a succession of ones.

$$\begin{array}{r}
 1'23'45'67'89 \text{ (} 111'111 \text{)} \\
 1 \\
 \hline
 21 \text{) } 23 \\
 \underline{21} \\
 221 \text{) } 245 \\
 \underline{221} \\
 2221 \text{) } 2467 \\
 \underline{2221} \\
 22221 \text{) } 24689 \\
 \underline{22221} \\
 222221 \text{) } 246800 \\
 \underline{222221} \\
 24579
 \end{array}$$

The process may be shortened as to any number of the last figures of the root as follows. Find by the rule in the text, half, or one more than half, the number of figures required, then proceed according to the contracted method of dividing decimals, cutting off one figure from the right of the divisor every time you divide, and not bringing down or annexing any more figures to the remainder. Thus, in the foregoing example, if it be required to carry the answer to three places of decimals, proceed as in the margin.

$$\begin{array}{r}
 1'23'45'67'89 \text{ (} 111'111 \text{)} \\
 1 \\
 \hline
 21 \text{) } 23 \\
 \underline{21} \\
 221 \text{) } 245 \\
 \underline{221} \\
 2221 \text{) } 2467 \\
 \underline{2221} \\
 246 \\
 \underline{222} \\
 24 \\
 \underline{22} \\
 2 \\
 \underline{2} \\
 2
 \end{array}$$

A square root may be found by a table of logarithms (Table 32) as follows:—Find the logarithm of the given number; the number corresponding to the half of this number is the square root required. Thus, to find the square root of 15·6.

Log. of 15·6 = $1\cdot193125 \div 2 = \cdot596562$ log. = 3·95 root. Ans.

Any number may be squared or cubed by the same means, it being only necessary to multiply the logarithm of the given number by 2 or 3; the number corresponding to the logarithmic product is the square or cube, as the case may be. And so a number may be involved to any power, by multiplying the logarithm of the number by the power; the product is the logarithm of that power.

To save the trouble of calculation the officer ought to provide himself with a

pairs, likewise commencing at the decimal point. The first figure of the required root will be the square root of the left hand period or of the greatest square contained in it. Subtract the square of this figure from the first period; to the remainder annex the next period for a dividend, and for part of a divisor double the part of the root already obtained. Try how often this part of the divisor is contained in the dividend wanting the last figure, and annex the figure thus found to the parts of the root and of the divisor already determined. Then multiply and subtract as in division; to the remainder bring down the next period, and adding to the divisor the figure of the root last found, proceed as before. Continue the process till all the figures in the given number have been used; and if any thing remain, proceed in the same manner to find decimals or additional decimals, as the case may be, adding to find each figure, two ciphers, or if the given number end in an interminate decimal, the two figures that would next arise from its continuation.

*To find a mean proportional between two given numbers.**

table of squares and roots comprehending such numbers as most frequently occur in his practice. See *Ballard's Gauging*, p. 125.

* EXAMPLES.

(1.) Required the geometrical mean proportional between 36 and 64?

$$64 \times 36 = 2304 \text{ (48 Ans.)}$$

$$\begin{array}{r} 16 \\ 88 \overline{) 704} \\ 704 \end{array}$$

(2.) Required the geometrical mean proportional between 2.5 and 57.6?

$$57.6 \times 2.5 = 144 \text{ (12 Ans.)}$$

$$\begin{array}{r} 1 \\ 22 \overline{) 44} \\ 44 \end{array}$$

This rule is extensively applied in Excise calculations to the measurement of certain bodies which have unequal dimensions, especially where it is required to find the area in gallons, bushels, &c., at one operation. A mean proportional may be found more readily by a Table of Logarithms (Tab. 32), as follows: Add the logarithm of one of the given numbers to that of the other, and divide the sum by two; the number answering to the quotient (disregarding the index) is the mean proportional required. Thus, in the foregoing examples:—

Log. of 36 = 1.556303

$$64 = 1.806180$$

$$2) 3.362483$$

$$1.681241 \text{ log.} = 48 \text{ Ans.}$$

Log. of 2.5 = .397940

$$57.6 = 1.760422$$

$$2) 2.158362$$

$$1.079181 \text{ log.} = 12 \text{ Ans.}$$

For ordinary purposes a mean proportional may be found still more readily by the Sliding Rule (p. 64), or by a Table of Mean Proportionals, which may be readily made by either of the foregoing methods.

—Multiply the two numbers together and extract the square root of the product ; the root will be the answer.

Directions for extracting the *cube root*,* together with a

* The operation necessary for extracting the cube root by the pen is very tedious, but for ordinary purposes, the root may be found sufficiently near by the Sliding Rule (see p. 65). It is proper, however, that the officer should know the principle upon which the operation is founded, and this will be understood by the following general rule :—

Place in succession and at moderate intervals two ciphers and the given number, as the commencement of three columns. Beginning at the unit figure of the given number, cut off as many periods as possible of three figures each. For the first figure of the root take the root of the greatest cube contained in the left hand period. Place this figure in the first column, and having added it to what stands above it, multiply the sum by the same figure, writing the product in the second column. Add in like manner in the second column, and multiply the sum by the same figure. Set the product in the third column, and subtract it from what stands above it. Perform a process exactly similar in the first and second columns, and after that, add the figure found for the root to what stands in the first column. Annex one cipher in the first column, and two in the second ; and in the third the next period of the given number ; or if there be no figures remaining, annex three ciphers. To find the next figure of the root, divide the number in the third column by the one in the second ; place this figure in the first column, and proceed in the manner directed for the first series ; then annex ciphers, and continue the process as before, until nothing remains, or until the root is carried out to as many places as may be considered necessary ; as in the annexed example for finding the cube root of 926859875 :—

0	0	926'859'375(975 Ans.
9	81	729
9	81	197859
9	162	183673
18	24300	14186375
9	1939	14186375
270	26239	
7	1988	
277	2822700	
7	14575	
284	2837275	
7		
2910		
5		
2915		

The cube root may be readily found by a Table of Logarithms (Tab. 32), as follows :—Divide the logarithm of the given number by 3, the quotient is the logarithm of the root. Thus, to find the cube root of 44·3—

Log. of 44·3 = 1·646404 ÷ 3 = ·548801 = 3·54 cube root. Ans.

The student must bear in mind that the cube root is not the square root of

general rule for extracting any root whatever, are given in the notes.

the square root, but only the root of a number which, when multiplied twice by itself, will produce the given number. If the cube were the square of a square, it would be easy to find the root by two extractions of the square root, a mode of working which is applied to what is called finding the *fourth* root. The sixth root also may be extracted by extracting the third root of the given number, and the second root of the result, and other roots may be found in the same way. The following is a useful approximative rule *for finding any root whatever*: Call the index of the given power n , and find by trial a number nearly equal to the required root, and call it the *assumed root*. Raise the assumed root to the power whose index is n ; then, as $n + 1$ times this power added to $n - 1$ times the given number, is to $n - 1$ times the same power added to $n + 1$ times the given number, so is the assumed root to the true root, nearly. The number thus found may be employed as a new *assumed root*, and the operation repeated to find a result still nearer the true root. Thus, if it be required to find the 365th root of 1.06, we may take 1 for the assumed root, the 365th power of which is 1; and n being 365, we have $n + 1 = 366$ and $n - 1 = 364$. The work will then proceed in the following manner, and the answer will be found to be 1.0001596 :—

$$\begin{array}{r} 1 \times 366 = 366 \\ 1.06 \times 364 = 385.84 \end{array}$$

As 751.84

$$\begin{array}{r} 1 \times 364 = 364 \\ 1.06 \times 366 = 387.96 \end{array}$$

:

751.96 :: 1 : 1.0001596 Ans.

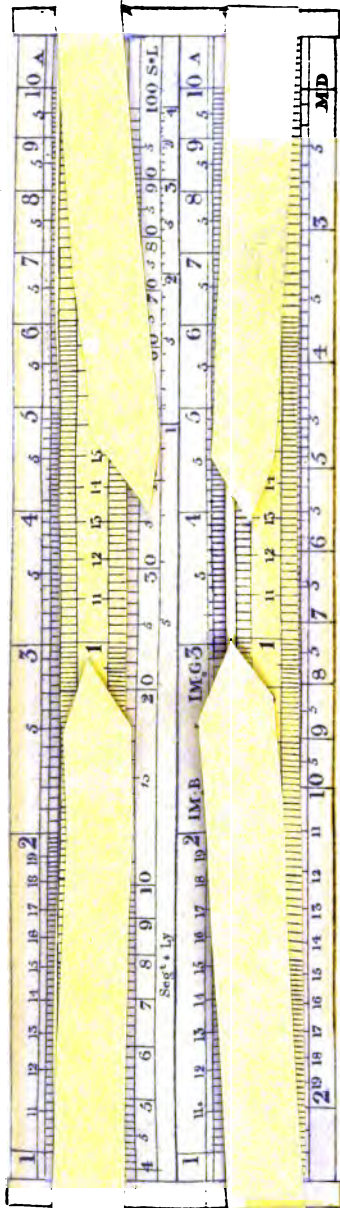
CHAPTER II.

THE SLIDING RULE.

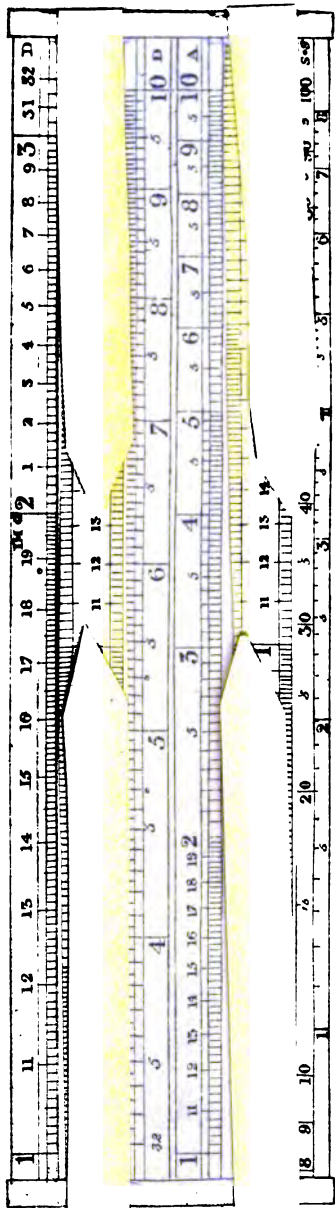
The Sliding Rule * is a portable instrument for facilitating mathematical calculations by the sliding of the different parts of the instrument one by the other; the lines and divisions upon the respective parts, giving the answers by inspection. It is, as to its principal lines or tables, founded upon the principle of logarithms.

The sliding-rules used in gauging are made in different forms and of different lengths, from six to twenty-four inches; but nine and twelve inches are the most common lengths. The one from which the annexed engraving is taken, is only six inches long, and has been adopted for the convenience of its size. In whatever form the instrument is made, it has always four lines or parts, known by the names, and marked by the letters, "A," "B," "C," and "D," and different marks called "*gauge-points*," varying with the particular business of the person using the rule; and all

* The sliding-rule is an instrument for the mechanical performance of addition and subtraction, which is converted into an instrument for the mechanical performance of multiplication and division by the use of logarithmic scales, instead of scales of equal parts. This instrument has been greatly undervalued in our country, in which it was invented, and is very little known on the Continent; for though a French work on the subject, published in 1825, which is followed by the writer of a very recent mathematical dictionary in the same language, assures us that in England, the sliding-rule is taught at schools at the same time with the letters of the alphabet; we feel safer in saying that nine Englishmen out of ten would not know what the instrument was for if they saw it; and that, of those who even know what it is for, not one in a hundred would be able to work a simple question by means of it. For a few shillings, most persons might put into their pockets some hundred times



DR. BATEMAN'S SLIDING RULE FOR REVENUE OFFICERS.



1

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sliding-rules applied to malt-gauging have a line marked "M D;" while those used for ullaging casks have two lines, marked respectively "S S," and "S L;" and sometimes there are three other lines marked "X," "Sphd," and "2 Var."

On some sliding-rules there are lines for reducing and valuing spirits; and on others of a larger size, there is sometimes a line of inches and tenths, and a line called a "diagonal" line; but these lines are more commonly graduated on separate rules, called "proof rules" and "diagonal rods."

I. THE LINES A AND B.

The line A is called *Gunter's line*, from its inventor, Mr. Edward Gunter, who, in the year 1624, first made the discovery of applying logarithms * to extension, and of performing upon this line, by means of a pair of compasses, the

as much power of calculation as they have in their heads; and the use of the instrument is attainable, without any knowledge of the properties of logarithms, on which its principle depends.—*Penny Cyclopædia*.

This instrument has always been a cherished companion of the excise officer, to whom many of its most useful improvements are attributable.

* Logarithms are natural numbers, or numbers in arithmetical progression corresponding with or having relation to other numbers in artificial or geometrical progression. If we take a set of numbers going on by equal differences, that is to say, the third being as much greater than the second as the second is greater than the first, as 1, 2, 3, 4, 5, 6, &c., where the common difference is 1; this is *Arithmetical Progression*. Then take another set of numbers, such that each is equal to twice or three times, or any number of times, the one before it, as 2, 4, 8, 16, 32, 64, &c.; this is *Geometrical Progression*. If we write this second set of numbers under or by the side of the first, thus—

0	1	2	3	4	5	6	7	8
1	2	4	8	16	32	64	128	256

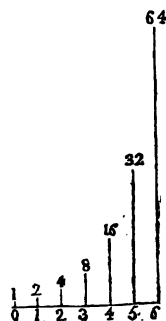
it will be found that if any two of the indices, or arithmetical series, be added together, their sum will be the logarithm of the *product* of the numbers to which they belong; and if any one of the indices be subtracted from another, their *difference* is the index of the *quotient* of the numbers. Thus, 2 and 3 are 5; the number against 5 is 32, which is the *product* of 4×8 , whose logarithms are 2 and 3; and so 5 from 7 leave 2—the logarithm corresponding to 4, the quotient of 128 by 32. Hence it appears that *addition* of logarithms answers to *multiplication* of common numbers, and *subtraction* to *division*; and tables have been constructed giving the logarithms of all

business of multiplication, division, and various arithmetical operations, where the rule of proportion was required. This line, which, from its utility, is sometimes also called the "Line of lines," and the "Line of numbers," contains a scale or radius of graduated logarithms, numbered from the left to the right, with the figures 1 2 3 4 5 6 7 8 9 10, and the spaces between each of these integers are again graduated into subdivisions, more or less minute, according to the length of the space.

When this line takes up the whole extent of the fixed part of the rule, and the numbers run in regular progression,

numbers from 1 to 10,000 and more; so that instead of multiplying and dividing one number by another, you have only to add or subtract their logarithms, and then you at once find the product or quotient in the Tables. Now, numbers are but expressions for the measure of distances from a fixed point, and therefore it follows, that if from the commencement of any line, as 0, we set off equal distances in the points 1, 2, 3, 4, &c., and raise against them a series of perpendiculars, 1, 2, 4, 8, &c., increasing in length in proportion as their distances from 0, we shall have in the extremities of these perpendiculars a series of distances 1, 2, 4, 8, &c., whose logarithms will be the distances 0, 1, 2, 3, &c. These, representing the indices of the distances measured by the perpendiculars, will, of course, possess the same properties as the indices themselves; and by the application of the compasses from one part of the indices to the other, we attain the same results as if we operated by arithmetical calculation. Thus, if it be required to multiply 16 by 4: with a pair of compasses take the distance from 0 to 2—the index corresponding to 4; set one foot of the compasses on 4—the index of 16, the other point will reach forward to 8—the index of 64, the product of 4 and 16. It is, however, evident that, as far as the solution of questions is concerned, the perpendiculars are of no importance, the *equal* distances and the *increasing* numbers being all that are required. If, then, we affix the progressive numbers, or logarithms, answering to the indices at the places where, in a scale of equal parts, the indices themselves would be placed, such logarithms may be applied to the usual purposes to which logarithms are adapted.—See *Kentish's Treatise, &c.*

Such was the invention of Gunter's famous line, which is a scale or radius of graduated logarithms, numbered from 1 to 10, with sub-divisions more or less minute according to the space occupied; and it is still used in conjunction with a pair of compasses, especially by Navigators. But the use of compasses is both troublesome and liable to error; and to obviate these objections a plan was invented of sliding one line of numbers by another, and thus attaining the same results. It was seen that the operations of multiplying and dividing with the compasses were merely applications of the Rule of Proportion, and it was therefore concluded that, if the line was made in



it is (in whatever part it may be placed) marked with the letter "A."

In modern sliding-rules there are usually two or more of these lines exactly alike, which affords the facility of working two questions, or double proportion, at the same time. In the annexed engraving there are three such lines. On some rules there is a double radius marked with the same letter, but the modern rules have only a single radius, as in the engraving.

The line B is on a moveable slider, which is made to run in a groove, within or under the line A. It contains

duplicate, one part sliding by the other, the answers to the questions, which had hitherto been found by the compasses, would be shown by inspection of the lines when moved the proper distances. This improvement is said to have been effected in 1683, and is generally attributed to Mr. Thomas Everard, formerly an Officer, and afterwards a Collector of Excise; and the first Excise Officer's sliding rules were usually called "Everard's rules." But it appears from the researches of Professor De Morgan, that moveable slides were invented by the Rev. W. Oughtred, and substituted for the scale and compasses more than 50 years before the time of Everard's "improvement;" and that in 1635 Seth Partridge introduced the slider fitted into a groove.

"In the original sliding-rule the line A contained a double radius, but Mr. Vero, some time Collector of Excise, made an alteration in it, so that the whole length of the rule had but one radius, while two of the sliders were made to fit in and work together as a double radius."—*Leadbetter*. A single radius is, in fact, insufficient to solve *all* multiplications and divisions, although $1\frac{1}{2}$ will serve. In modern Rules, therefore, there are sometimes two lines upon the stock, one above the slider and the other below it, and two lines on the slider, the radii on the upper lines beginning with 1 at each end, and those on the lower lines with 1 in the middle. By this ingenious contrivance it is unnecessary to use more than one slider.

Many other modifications of the rule have been devised during the eighteenth and present centuries, chiefly to suit specific purposes.

The most simple form, and, but for the difficulty of dividing, probably the best, is a revolving circle turning upon a fixed axis, in which case the scale is its own continuation; and this appears to have been one of the forms in which it was originally introduced by Oughtred. In this way an Excise Officer has occasionally graduated it upon his tape box, and a Frenchman upon his snuffbox. And Professor De Morgan is of opinion, "that when the knowledge of this instrument is extended, and consequently its sale, a pair of well-graduated brass circles will be the form it will take."

To Construct the Line of Numbers.—Divide the line intended to be numbered into 1000 equal parts, and set off the distances by the Table of Logarithms (No. 32), disregarding the characteristics. Thus, the distance from 1 to 2 will be '30103 of the parts, this number being the logarithm of 2; the distance from 1 to 3 will be '47712, the logarithm of 3, &c. But a more expeditious and exact method of laying down the line is by means of a sector, as described in *Moss's Gauging*.

the same scale (Gunter's line of logarithms) as the line A, and has always a counterpart, also marked with the letter "B," which being taken out of the groove in which it usually rests, and put into the same groove with its counterpart, the two brass ends of both being made to fit together, they become a double radius numbered from left to right. By moving the slider in the groove until it is properly adjusted, problems which formerly required the use of the compasses are solved by inspection.

In the engraving, all the sliders have double radii, which was necessary in order to show the method of working; but in the instrument itself the sliders are only of the same length as the rule, for the convenience of the pocket.

On each of the lines "A" and "B," there are brass pins or marks against the *divisors* for squares and circles for facilitating the operations when the answer is required in gallons or bushels, &c.*

To estimate the value of the numbers.†—The numbers on Gunter's line have no determinate value of their own, but depend upon the value that is set upon the unit at the left hand of the line, which may be considered either as 1, 10,

* See the Note in p. 58.

† To distinguish the different numbers on the line, and, after an operation, to read off the answer, constitute with learners the great difficulty. It is only by attention and practice that facility in this respect can be attained. It must be observed that from 1 to 2 the tenths are usually divided into five parts, each part containing two hundredths; therefore,

If the figure 1 $\left\{ \begin{array}{l} .1 \\ 1 \\ 10 \\ 100 \end{array} \right\}$ then the larger $\left\{ \begin{array}{l} .01 \\ .1 \\ 1 \\ 10 \end{array} \right\}$ divisions will represent and the smaller $\left\{ \begin{array}{l} .002 \\ .02 \\ .2 \\ 2 \end{array} \right\}$ divisions

From 2 to 5 the tenths are divided into two parts, each part containing five hundredths; therefore,

If the figure 2 $\left\{ \begin{array}{l} .2 \\ 2 \\ 20 \\ 200 \end{array} \right\}$ then the larger $\left\{ \begin{array}{l} .01 \\ .1 \\ 1 \\ 10 \end{array} \right\}$ divisions will represent and the smaller $\left\{ \begin{array}{l} .005 \\ .05 \\ .5 \\ 5 \end{array} \right\}$ divisions

From 5 to 10 the tenths are not divided; the hundredths, therefore, must be guessed at. And

If the figure 5 $\left\{ \begin{array}{l} .05 \\ .5 \\ 5 \\ 50 \end{array} \right\}$ the tenths will represent $\left\{ \begin{array}{l} .01 \\ .1 \\ 1 \\ 10 \end{array} \right\}$

The integral numbers, or principal divisions in the second radius, being ten

100, 1000, &c. If the first figure be called 1, the following integral numbers will be 2, 3, &c.; and should there be a second radius, the first integer will be 10, and the integral figures which follow will be 20, 30, &c., and the 10 at the right hand end will be 100. If the first or left hand unit be considered 10, the 2 will be 20, the 3, 30, &c., and the first unit on the second radius will be 100, and the following figures will be 200, 300, 400, &c., and the 10 at the right hand will be 1000. And if the first or left hand unit be called 100, the first unit on the second radius will be 1000, and the following figures 2000, 3000, 4000, &c., and the 10 at the right hand 10,000.

The values of the integral divisions being thus estimated, those of the intermediate divisions may be easily known.

*To find the product of two given numbers.**—Set 1 on B to either of the numbers on A, then against the other number on B is the required product on A.

times the value of those in the first, its subdivision will be in the same proportion, or ten times the value of the subdivisions of the former.

For the purpose of becoming familiar with the mode of valuing and reading off the divisions, the slider may be set at random, and the officer may accustom himself to read off in the respective pairs the divisions on one line corresponding to any assumed values on the other. All values may in general be estimated to three places of figures, thus:—

A		41	50	73·8	150	225	451	549	820	
B		1	1·22	1·8	3·65	5·49	11	13·4	20	
A		·245	·521	1·04	1·53	1·84	2·45	4·1	6	
B		·4	·85	1·7	2·5	3	4	6·7	9·8	

“When there are two or more modes of performing the same operation and two or more numbers are given or required which can be *exactly* expressed on the sliding rule, while there is another number which can only be *estimated*; that mode of operation should be adopted which would place an *exact* value opposite an *estimated* one, and *vice versa*.”—*Woolgar*.

* EXAMPLES IN MULTIPLICATION.

- (1.) Required the product of 13×9 ?

A		9 (multiplier)	117 (product)		A		13	117	Ans.
B		1	13 (multiplicand)	or,	B		1	9	

If the product be too large to be read on the rule, either of the factors may be divided by 10 or 100, and after the first product has been obtained it must be multiplied by the number by which the factor was divided. If the product consists of more than three or four figures it is difficult to read them on the rule, but it will be easy to bear one or two of them in memory. Thus, if it be required to multiply 56 by 38 the product will be 2128; the last figure is known to be 8 by multiplying 6 by 8 mentally; and it is evident from the rule, that the product is more than 2118 and less than 2138.

To find the quotient of two given numbers.—*Set 1 on B to the divisor on A, then against the dividend on A is the quotient on B.

*To perform the Rule of Three.†—*As the first term upon

Multiplication may also be performed by inverting the slider, thus :—

$$\begin{array}{r|l} \text{A} & 9 \quad 1 \\ \hline \text{Q} & 13 \quad 117 \text{ Ans.} \end{array} \qquad \begin{array}{r|l} \text{A} & 13 \quad 1 \\ \hline \text{Q} & 9 \quad 117 \text{ Ans.} \end{array}$$

It is obvious, therefore, that any number may be squared by this inversion of the sliders, and the square root may also be found by it, by setting the given number on Q against 1 on A; then look for a number on A which coincides with the same number on B, and this number is the square root required.

* EXAMPLES IN DIVISION.

Divide 795 by 5.

$$\begin{array}{r|l} \text{A} & 5 \text{ (divisor)} \quad 795 \text{ (dividend)} \\ \hline \text{B} & 1 \quad 159 \text{ (quotient)} \end{array} \quad \text{or,} \quad \begin{array}{r|l} \text{A} & 1 \quad 159 \\ \hline \text{B} & 5 \quad 795 \end{array} \quad \text{Ans.}$$

If the dividend cannot be properly expressed on B, it may be divided by some power of 10, so as to bring it within the rule, and the quotient, when found, multiplied by the same power (*vide supra*).

Division may also be performed, and the square root extracted, by inverting the slider as directed in multiplication.

When any particular *divisor* is of frequent occurrence, as is the case with that representing the number of cubic inches in a gallon and bushel respectively, it is distinguished on the rule by a brass pin and an initial letter; thus, at 277·274 there is a brass pin and the letter G, to indicate the *divisor for gallons*; and at 2218·192 there is another pin and the letter B, being the *divisor for bushels*. See p. 23. Then, for reducing inches (say 30,000) into gallons or bushels by the above rule, set the proper divisor on A, to 1 on B, and against the given number of inches on A is the answer in gallons or bushels on B; thus—

$$\begin{array}{r|l} \text{A} & \text{G } 277\cdot274 \quad 30000 \\ \hline \text{B} & 1 \quad 108\cdot2 \text{ gall.} \end{array} \qquad \begin{array}{r|l} \text{A} & \text{B } 2218\cdot192 \quad 30000 \\ \hline \text{B} & 1 \quad 13\cdot5 \text{ bus.} \end{array}$$

The use of these divisors will be further shown in *MENSURATION*.

A vulgar fraction may be reduced to a decimal by this rule, the denominator being considered as the divisor, and the numerator as the dividend. This operation is, in effect, as explained in p. 30, the same as finding a *factor*, which, being used as a multiplier, produces the same result as any given *divisor*. Thus, if it be required to find a factor for reducing ounces to pounds weight by multiplication, instead of dividing by 16, we say :—

$$\begin{array}{r|l} \text{A} & 16 \text{ oz.} \quad 1 \text{ or } 1000 \\ \hline \text{B} & 1 \quad \cdot0625 \text{ factor.} \end{array}$$

† EXAMPLES IN PROPORTION.

All questions in Arithmetic, usually inserted under the head of Proportion or Rule of Three, are readily solved by the lines A and B on the sliding rule. The lines are in reality *proportional* lines. When the slider is laid *evenly* in the groove, that is, when the commencement of A coincides with the commencement of B, the numbers on A are the *same* as the numbers on B; but when the slider is in any other position, the numbers on A are proportional to the numbers on B. Thus, let the slider be drawn back until the 2 of B falls under the 1 of A, then we have a series of continued proportionals or equivalent fractions, the odd terms or numerators standing above the even

A is to the second term upon B, so is the third term upon A to the fourth term upon B.

terms or denominators. As $\frac{1}{2} = \frac{2}{4} = \frac{3}{6} = \frac{4}{8} = \frac{5}{10}$, &c., or $1 : 2 :: 2 : 4 :: 3 : 6 :: 4 : 8 :: 5 : 10$. &c.

(1.) What is a fourth proportional to the numbers 12, 24, 36?

$$\begin{array}{r} \text{A} \mid 24 \dots 72 \\ \hline \text{B} \mid 12 \dots 36 \end{array} \quad \text{Ans.} \qquad \text{Or} \qquad \begin{array}{r} \text{A} \mid 12 \dots 36 \\ \hline \text{B} \mid 24 \dots 72 \end{array} \quad \text{Ans.}$$

As the lines on the sliding-rule are graduated decimally, they are especially well adapted for the concise solution of different questions in which the standard of comparison is fixed at an even number of tens, hundreds, &c., as is the case with *specific gravities* in which 1000 is reckoned as the standard of water, with which all other bodies are compared (pp. 22, 42); and *spirits*, the standard or proof of which is reckoned at 100 (p. 44). A few examples, founded on those already given, will be sufficient to show the manner in which the operations are performed:—

(2.) Required the specific gravity of a quantity of soap weighing 30 lbs. in air and 16.35 lb. in water? (P. 42.)

A	30	.. 1.021 sp. gravity.	Ans.
B	29.365 (lbs. lost weight)	.. 1000 (water).	

(3.) Reduce 40 gallons of spirits at 30 o. p. and $25\frac{1}{2}$ gallons at 32 u. p. respectively to proof. (P. 44.)

A	130	..	52 gallons proof.	A	68	..	17.34 gallons proof.
B	100	..	40	B	100	..	25.5

(4.) Reduce 40 gallons of spirits at proof to 30 per cent. *w. p.*; and 32 gallons at 25 per cent. *w. p.* to 20 *o. p.* (P. 44).

A	1	..	57.14	galls. at 30 o. p.	A	1	..	20	galls. at 20 o. p.
B	70	..	4000	(=40 galls. proof $\times$ 100)	B	120	..	2400	(=32 $\times$ 75)

The application of the lines A and B to finding the areas of squares, circles, &c. will be shown in Mensuration of Superficies.

The decimal graduation of the rule, however, renders it difficult to apply it to questions relating to money, weights, or measures involving broken quantities. Still, this has been done to some extent, in cases where the answer is required in integers, and when there is a known ratio between any two numbers and one of such integers. Thus, if it be required to find the number of shillings per calendar month for every pound of *yearly* expenses, wages, &c., it must first be ascertained what is the ratio between £1 per year and 1s. per month, which is found to be as 3 : 5. Then, whether by the pen or on the sliding-rule, the formula is 3 : 5 :: the number of pounds per year : the number of shillings per month. And so with respect to other ratios, examples of which are as follows:—

A		73		.. pounds per year.			
B		112 (28)		[4] .. shill. per lun. mo. (week) [day]			
Interest simple		A	365	(52·1)	[12]	.. days	(weeks) [months]
5 per cent.		B	pounds principal		.. shillings interest		
Other rates		3	3½	4	4½	6 per cent.	
		608	548	521	456	408	304 for days.
Divisors		86·9	78·2	74·5	65·2	57·9	43·5 for weeks.
		20	18	17	15	13·3	10 for months.

By a slight alteration in the graduation in the rule, however, it may be usefully applied to broken numbers, as will be seen from the following circumstance. When the duty was on crown glass, it was the custom to weigh the tables as they were drawn out of the annealing arch, not in single tables, as

II. THE LINES C AND D.*

The line D is also a Gunter's line, constructed in the same manner as the lines A and B, only it has double the power; the distance between 1 and 10 being twice as long, and the other divisions in proportion. On the Excise

these are too brittle for handling, but in crates containing from 1 to 50 tables each; and the drafts and number of tables were taken down as they were weighed. In an investigation a few years ago, it became necessary to show the *average* weight of a great number of tables weighed in this manner at each weighing for a series of years. And this could only be done by *dividing* the weight in each case by the number of tables weighed. This extended to many thousands of calculations, and employed a number of persons many weeks. It became important, that *one* person should prepare himself to verify these calculations at a short notice; and I thereupon proposed to assist him by an additional graduation on the sliding-rule, dividing each integer into sixteenths on the stock of the rule, so as to give the answers in lbs. and oz., instead of lbs. and tenths. The result was, that one person checked in a few days, what had taken many weeks in calculating, and many mistakes which had been made by the pen, were discovered and corrected into the bargain.

* These lines are founded on another of the principles of a logarithmic series (explained in p. 53), namely, that if any one of the indices be *multiplied* by another denoting any *power* or multiple of the other, the product will be the index of that *power*. And if the index of any number be *divided* by the index of any *root*, the quotient will be the index of that *root*. Thus, to find the *square* of 8; its index (referring to the two series of numbers in p. 53) is 3, which doubled becomes 6, the index of 64, the square of 8 as required. And so, to find the *square root* of 16; its index is 4, the half of which, 2, is the index of 4, the square root of 16 as required. Whence it follows, that the multiplication of logarithms answers to the Involution of common numbers; and division to Evolution. Hence, if on the graduated line in p. 54, it be required to find the *square* of any number, say 8, we have only to measure the distance from 0 to 3, the index corresponding to 8, and then place the compasses on the point 0, and turn them over twice; they will reach to 6, the index of 64, the square required. And so, to find the *square root* of 64; take half the distance from 0 to 6, which is the point 3, the index of 8, the square root required. But for taking squares and square roots, it is more convenient to have the logarithmical distances laid down to two scales, in which the distances of the latter shall be twice those of the former. We have then only to ascertain the distance of any division of one series, and apply it to the other to obtain at once the index to the square or square root of any given number. Hence, if we fix on two scales the progressive numbers or logarithms answering to the indices at the respective places where the indices themselves would be placed, we have a table of squares and roots, and by making one of such squares moveable, we are enabled to work upon them questions which would otherwise involve the tedious and difficult operation of Involution. Such are the lines C and D; the one furnishing a series of numbers corresponding with the squares and square roots on the other. When the commencement of C coincides with that on D, the two lines form a series of squares and roots; but when the slider is in *any other* position, the numbers on C are *proportional* to the *squares* of those on D. Thus, let the

officer's sliding rule this line is usually divided into two; one half being above the slider, and numbered from left to right, with the figures 1, 11, 12, 13, 14, 15, 16, 17, 18, 19, 2, 1, 2, 3, 4, 5, 6, 7, 8, 9, 3, 31, 32; and the other half continued on the stock below the slider, namely, 32, 4, 5, 6, 7, 8, 9, 10; at which point it terminates opposite 3.162 (square root of 10), on the upper part.

Operations on this line are performed by means of two sliders, marked "C," which are exactly the same as those marked "B," and are differently named only for the sake of distinction. The line B may, indeed, be used instead of the line C, when the former is found more convenient.

To estimate the value of the numbers.—The value of the numbers on the lines C and D, are estimated in the same manner as those on the lines A and B, but as the subdivisions on D are more minute than those on A, B, and C, there being more room on the line for graduating them, they must be estimated accordingly.

When the two lines C and D are laid evenly in the groove they form a series of *squares* and *square roots* to each other. In any other position the numbers on C are proportional to the *squares* of the numbers on D, and many questions relating to *squares* and *square roots* can thus be solved by the two lines in the same way that multiplication

slider be drawn back until the 2 on C falls under the 1 on D, then we have a series of continual proportionals, or equivalent fractions, as

$$\frac{2}{12} : \frac{8}{22} = \frac{18}{32} = \frac{32}{42} \text{ \&c., or as } 2 : 12 :: 8 : 22 :: 18 : 32 :: 32 : 42 \text{ \&c.}$$

In estimating the numbers on the lines C and D, it must be observed, that if the 10 on D be called 1, the 1 on C will be 10; if the 10 on D be called 10, the 1 on C will be 100; if the 1 on D be called 100, the 1 on C will be 1000, &c.

On some rules the line D is on one side of the slider B, and the line A on the other; an arrangement which gives an additional power in working various questions: for we can thus, at one setting, find the product or quotient of any two numbers, and the square root of their product or quotient. We can also multiply any number by the square or square root of another number, &c. This arrangement is, however, impracticable on the Excise Officer's Sliding-rule, in consequence of the line D being divided into two parts, one above and the other below the slider; but it fortunately happens, that the operations involved in it, do not often occur in excise practice.

and division of common numbers can be performed by the lines A and B.

The line D, like the line A, has various brass pins or marks against certain numbers which, to distinguish them from those on the other lines, are called "*Gauge Points*." * These gauge points, are, in fact, the square roots of different numbers which are of frequent occurrence in excise calculations. Thus at 47·10 is a brass pin with the mark "M S." which is the gauge point for malt bushels, that number being the square root, or side of a square whose area is exactly one bushel. At 16·65 is another pin, with the letters "G S." for the gauge point of a gallon. And at 53·14 and 18·79 are also pins with the marks "M R." and "G." or "M G.," the gauge points for a circular bushel and gallon respectively.

To square any given number.†—Set 1 on C to 1 on D; then against the proposed number on D is its square on C.

* A "*Gauge Point*" is the square root of any number which in common arithmetic would be used as a *divisor* for reducing one kind of magnitude into another. Thus, if we require to reduce inches to gallons, we must, in numerical calculation, divide the given number of inches by 277·274, the number of inches contained in a gallon. If we extract the square root of this divisor, we obtain the side of a square whose area is a gallon; the *side* of every square being the *square root* of its area; and the root thus obtained, (16·65), is called the *square gauge point* for gallons. For, using it as a starting point upon the lines C and D, we can ascertain the proportion between it and any other square, and thus obtain the *area* of any square, or the *content* of any square vessel which can be compared with a square whose area is a gallon. And so, if we extract the square root of 2218·192, the number of inches in a bushel, we obtain the side of a square, or the square root of a square, whose area is exactly *one bushel*, viz. 47·1, which we call the *square gauge point* for bushels. Again, the diameter of every circle is the square root of the circular divisor (p. 85); hence, if we extract the square root of 353·086, (which is equal to $277\cdot274 \div \cdot7854$) (p. 85), we obtain the diameter of a circle whose area is exactly one gallon; viz. 18·789, which we call the *circular gauge point* for gallons. And so, if we extract the square root of 2824·29, ($= 2218\cdot192 \div \cdot7854$), we obtain the diameter of a circle whose area is exactly one bushel; viz. 53·14, which we call the *circular gauge point* for bushels. These gauge points being distinguished on the sliding rule by particular marks, are of great importance in practical gauging, being used as the first term, or ratio, in working problems in Mensuration, as will be explained in subsequent pages. A Table of the gauge points most commonly required in Excise calculations, with their corresponding divisors and factors, will be found in the Appendix, No. 30.

† EXAMPLES IN SQUARES AND SQUARE ROOTS.

The lines C and D, when laid even, being the squares and square roots of each other, the only difficulty is in estimating the value of the different

To extract the square root.—Set 1 on C to 1 on D ; then against any proposed number on C is its square root on D.

*To square a given number and divide the product by another given number.**—Set the square root or gauge point of the divisor on D to 1 on C ; then against the other given number on D is the answer on C.

numbers. The following are examples when 1 on C and D are both whole numbers :—

C		1	2.25	5	10	16	25	40	90
D		1	1.5	2.24	3.16	4	5	6.32	9.5

With the same setting as the last, but valuing 1 on D at .1 :—

C		.01	.0225	.05	.1	.16	.25	.4	.9
D		.1	.15	.224	.316	.4	.5	.632	.95

In looking for the square root of any number, it is important to remark, that if the square contains an odd number of integers, or a decimal having an odd number of ciphers, before the first effective figure, the root will be found opposite on the first radius on D ; but if the square consists of an even number of places, the root will fall against the second radius. As a general rule, the whole numbers or integers in the root will be half as many as those in the square, if the whole numbers or integers in the latter be even ; if not it will be half as many and one more. The rest of the answer in either case will be decimals.

* EXAMPLES OF GAUGE POINTS.

- (1.) Square 40 and divide by 2218.192.

C		1	.721 Ans.
D		47.1 (square root of 2218.192)	40

- (2.) Square 40 and divide by 353.036.

C		1	4.5 Ans.
D		18.79 (square root of 353.036)	40

- (3.) Multiply 60 by 38² and divide by 2824.29.

C		60	30.67 Ans.
D		53.14 (square root of 2824.29)	38

- (4.) Multiply 60 by 38² and divide by 353.036.

C		60	245.4 Ans.
D		18.79 (square root of 353.036)	38

These examples show the way in which gauge points are used, as explained in p. 62. The gauge points here used are the square roots of the measures there referred to. The first example is, in effect, the same as finding the area of a *square* one inch deep, the side being 40 inches, and the area being found in bushels, each of which contains 2218.192 inches, the square root of which is 47.1. The second is the same as finding the area of a *circle* one inch deep, the diameter being 40 inches, and the area being found in gallons, each equal to 353.036 ($= 277.274 \div .7854$), the square root of which is 18.79. The third and fourth are the same as finding the content, in bushels and gallons respectively, of a cylinder, whose diameter is 38 inches and depth 60. Many other examples of the application of gauge points will be found in the various sections of Mensuration, *infra*.

To square one number, multiply by another, and divide by a third.—Set the square root or gauge point of the divisor on D to the second number on C; then against the number to be squared on D is the answer on C.

*To find a square number which has to a given square number the same proportion that two given simple numbers bear to each other.**—Set one simple number on C opposite to the given square number on D; then opposite the other given number on C is the square number sought on D.

To find a square root which has the same proportion to a given square root, that two simple given numbers have to each other.—Set one of the simple numbers on C opposite to the given square root on D; then opposite to the other simple number on C is the square root required on D.

To find a number which shall have to a given one the same ratio which the squares of two given numbers have to one another.—Set the first term of the ratio on D to the given number on C; then opposite to the other term of the ratio on D stands the answer on C.

To find a number which shall be to a given one as the square roots of two given numbers.—Set the first term on C to the given number on D; then against the other term on C stands the answer on D.

To find a mean proportional between two given numbers, or to extract the square root of the product of two given num-

* EXAMPLES TO PROPORTIONALS, SQUARES, &c.

(5.) Find a square number which bears the same proportion to 1^2 as 9 bears to 81.

C		9	81
D		1^2	3^2 Ans.

(6.) Find a square root which has the same proportion to the root 3 as 81 bears to 9.

C		81	9
D		3	1 Ans.

(7.) Required the number which shall be to 12 as the square of 9 is to that of 3?

C		12	108 Ans.
D		3	9

(8.) To what number will 3 have the same ratio, as the square root of 108 to that of 48?

C		108	48
D		3	2 Ans.

The accuracy of these calculations may be tested by the pen, or by the lines A, B, by squaring the numbers on D, and then operating as in simple proportion. Thus, in Ex. (7); $3^2=9$, and $9^2=81$; then $9:12::81:108$.

*bers.**—Set the less number on C to the like number on D ; then against the other number on C is the mean proportional on D.

To cube a given number.†—Set 1 on D to the root or given number on C ; then against the root on D is the cube on C.

To extract the cube root of a given number.—Move the slider either way, until 1 at the beginning of the line D, 10 at the end of the line D, and the given number on C, cut the same number on the opposite lines, and that number will be the root required.

III. THE LINE M D.‡

The line M D, signifying “malt depth,” is a line similar

* EXAMPLES OF MEAN PROPORTIONALS.

This rule is of great use in the practice of gauging, and ought to be well understood by the excise officer.

(9.) Find a mean proportional between 4 and 9.

C		4		9
D		4	6	Ans.

(10.) Find a mean proportional between 3 and 12.

C		3		12
D		3	6	Ans.

The effect of placing the slider in this position is the same as if the 4 and 9 or the 3 and 12 had been multiplied together by the lines A and B, and the square root of the product found on the lines C and D. The object of finding these mean proportionals is chiefly to reduce parallelograms to squares, and ellipses to circles ; a square, whose side is 6 inches, being equal to a parallelogram, 12 inches by 3 ; and an ellipse, whose axes are 12 and 3, being equal to a circle whose diameter is 6, &c. The mean side or axis, having been thus obtained, is used for finding the area or content, which, by means of the gauge points, (p. 62), may then be done at one operation. (See p. 49.)

† EXAMPLES OF CUBES AND CUBE ROOTS.

(11.) What is the cube of 4 ?

C		4		64	Ans.
D		1	4		

(12.) What is the cube root of 8 ?

C		2		8
D		1	2	Ans.

The hint for this operation for extracting the cube root is said to have been given by Mr. Clarke Eades of Petersfield. If the sliding-rule contained a radius of treble power, such radius would be the cube of C without moving the slider. Another mode of extracting the cube root is by inverting the line C, and after setting the given number to 1, the root will be found where equal values coincide on the two lines, thus :—

C		64		4 root
D		1	4 root	

C		8		2 root
D		1	2 root	

‡ I cannot ascertain who was the first to adapt this ingenious contrivance

to A, B, and C, with this difference only, that it is a broken line of two radii, and the figures and subdivisions stand in an inverted order, beginning at 2218·192, the number of inches in a bushel, numbered from the right hand to the left, and ending at 2218·192 where it began.

to the sliding rule; but it seems to have been suggested by the remarkable property which two logarithmic lines bear to each other, when one is inverted or running in a direction contrary to the other. In this position, the inverted line furnishes a series of reciprocals to the numbers on the other line, and which numbers, being used as divisors, have the same effect as multiplying by the lines in the usual manner. When the lines A and B are set together in the regular way, we can only multiply two numbers together, unless we find a reciprocal for a third number, in which case we may obtain the product of three numbers. Thus, if it be required to find the product of $4 \times 7 \times 8$. The reciprocal of 4 is $\frac{1}{4}$ or ·25; hence, we have to divide 7 times 8 by ·25. Set ·25 on A to 7 on B, then under 8 on A is 224 on B. By inverting the slide and pushing it evenly in, that is, until 1 on B is under 10 on A, it will be seen that the numbers on B are the reciprocals of the corresponding ones on A; hence, if under the slider we lay down a line on the stock, similar to A, but in an inverted position, it will furnish a series of reciprocals; and then three numbers may at once be multiplied together, by taking one of them on this inverted line, one on the slider, and the third on A, under which we have the product on B. If, instead of laying down the inverted line, so as to make the commencement of it fall under the end of the slider, it be drawn out towards the right hand until some other number than unity stands under 1 on A; then the product of the three numbers will be divided by this constant number. Thus, suppose we wish to divide 7 times 8 times 6 by 2, that is, to find the value of $(7 \times 8 \times 6) \div 2$. Let the inverted line be placed so that the 2 shall fall under the 1 on A; then over the 7 of the inverted line place 8 of the slider B, and under 6 on A will be 168, the answer on B. The line M D is founded on these principles. The square divisor for bushels (2218·192) is adopted for the commencement of an inverted line of numbers of the same power as the line A, and this divisor being exactly under unity on A, which stands above the slider B, while the line M D is placed under it, the three lines can be used at one operation to find the content of a solid with three dimensions; the length being multiplied by the breadth and depth, and the product divided by the proper divisor, so as at one view to show the content on B in bushels.

The earliest mention of the reversed line that has come under my notice is in *Hunt's Mathematical Companion*, 12mo. 1697, p. 197. It is next mentioned in the first edition of *Dougharty's Gauging*, published in 1707, and it is generally supposed that this writer was the first who proposed its use for malt gauging. It is certainly the most compendious application of instrumental arithmetic that I have met with. Moess considers that questions of this kind may be easier solved by the lines A and B, and C and D, by first finding a mean proportional; but the experienced gauger, I believe, always, and justly, prefers this most convenient line. See *Shurtleiff's Gauging*, p. 52; *Mechanics' Magazine*, No. 913, p. 111; *Kentish's Treatise*, p. 85; &c.

Gutteridge remarks that, "it is not a little strange, that this most admirable method of gauging an unequal sided floor of malt, without any other trouble than the mere touch of the slide, should not have been made for, and adopted in gauging of every other species of measure; particularly as the tabulating of brewers' and other utensils is so very tedious." Yet, he adds, "so tedious is

This line is placed on the stock under one of the lines marked A (but separated from it by means of the groove, which allows the slider to pass through), and so arranged, that the 1, or 10, on this line M D, is placed directly opposite to B, or M B, on the line A; and if this 1, or 10, be called 1000, the last division at the left end of the rule

the application of the sliding rule, even in the hands of the most expert, that, what with finding a mean, then setting to the gauge point, then considering if the numbers be even or odd in reference to the radius out of which the result is to be taken, &c., the sliding rule is perfectly useless in such case; the operation even by the old tedious methods by the pen being far preferable." To remedy this inconvenience, he proposed that the line M D should be moveable, and that on its reversed side a similar line should be graduated for ale gallons. He also suggested, that a double radius of inverted logarithms, opening and closing with a hinge, should be substituted, when necessary, for the line M D, the respective gauge points on which (being in this case divisors) should be brought forward when wanted, and placed even with 10 on the right hand of A; and when so placed, the rule-line could be used in conjunction with the line B for any measure whatever, so as to obtain the content at one operation, in the same manner as the line M D is used for bushels. These suggestions do not appear to have been acted upon to any extent, and I apprehend, the practical officers would have a decided objection to the line M D being moveable, for fear of mistakes; but, perhaps, an additional line of numbers, with a line of inverted logarithms, extending beyond a single radius, so as to serve for measures of every description, might be an improvement.

In connexion with the line M D, a practical suggestion has been recently offered by Mr. Todd. He proposes that when there is a known proportion between a bushel and any other measure, such proportion shall be used as a *constant* gauge point upon the line M D, so that the answer may be found in the measure to which the proportion has reference. Thus, if it be required to multiply 50 inches by 30 and find the product in gallons instead of bushels; because 8 gallons are equal to 1 bushel, he makes 8 a constant gauge point, and says as 8 on M D is to 50 on B, so is 30 on A to 5.41 gallons on B. And so if it be required to find the product in pounds of common hard soap, hot, he makes the constant gauge point 79.2, because a pound of such soap bears that proportion to a bushel; and so with other measures. A further abridgment of the labour of calculation which he proposes is as follows:—Supposing three numbers are given, any one of which is in constant use, we may multiply such constant number by the constant gauge point above referred to, and use the product as a *modified* gauge point; and this will produce the same result, as if we had first used the constant gauge point and then multiplied by this constant number. Thus, soap frames are required by law to be 45 inches long, and 15 broad; we may, therefore, take one of these dimensions, say 15, as constant, and multiply it by the constant gauge point for common hard soap, hot, above referred to, $79.2 = 1188$. Then, if we wish to multiply the length of any frame by the breadth and the depth, say 12 inches, and reduce the whole to pounds of common hard soap, hot, at one operation, it may be done by this formula:— 1188 on M D : 45 on B :: 12 on A : 289 lbs. on B. See the Table of Divisors, Factors, and Gauge Points, No. 30, in the Appendix.

Instead of the line M D, the officers of the customs have an inverted line commencing with 144, to give the content in cubic feet of timber, &c.; and the principle has been extended to some other operations.

will denote 2218·192, the cubic inches in a bushel; but if 10 be called 1, the last division at this end will be 2·218, the same as the first division at the right hand end of the rule.

This line is used with the line A, and the slider B or C, for finding the content of rectangular and similar figures in bushels at one operation.

*To find the product of two numbers in bushels.**—Set one of the numbers on B to the other on M D, then opposite to 1 on A is the answer on B.

*To find the product of three numbers in bushels.**—Set one of the numbers on B to another on M D, then against the third number on A will be the answer on B.

IV. THE LINE X.†

The line X is a line of special gauge points, applicable to the gauging of casks. It was invented by the late J. Woollgar, Esq., F.R.A.S., and is graduated in the annexed engraving at the right hand of the groove, under the first slider, as will be seen by lifting up the slit part of

* EXAMPLES ON M D.

(13.) Find the product of 50 inches by 30 in bushels.

A		1
B		50 3·677 bushels. Ans.
MD		30

(14.) Find the product of the three numbers, 45, 15, & 12 inches, in bushels.

A		12
B		45 3·65 Ans.
MD		15

The further application of this line will be shown in Mensuration, *infra*.

† Mr. Woollgar's object in the invention of this ingenious line, was to shorten the operation for finding the content of casks. The usual mode of working in such cases was to reduce the cask, whatever might be its form, to an equivalent cylinder, by obtaining a mean diameter between the diameters of the head and bung; but to do this correctly by the pen was a tedious operation, and the formulae for the sliding rule gave only an approximate result. Mr. Woollgar's contrivance was, to place in the groove of the rule, under or by the side of the slider B, which for this purpose was used with a single radius, a line of special gauge points, applicable to the different kinds of casks; such gauge points being equivalent to the diameters of the respective casks, supposing them to be cylinders. For instance, when the head and bung of any cask are equal, the cask is a cylinder and the gauge point is 18·789, the proper circular gauge point. As the head and bung differ from such correspondence the

the slider near the middle 1 or 10. It is used in conjunction with the lines A, B, C, and D.

To find the content of a cask.—Set the head diameter on*

gauge point increases in certain defined proportions. But whatever it be, it is used as the mean diameter of a cylinder upon the lines C and D, in the same manner as the circular gauge point; so that when the line is set on the same side of the slider as the lines A, B, C, D, the content may be found by a single movement of the slider B, and another of the slider C. The only disadvantage of this line is that the gauge point is not fixed, as is the case with the circular gauge point; and on this account it has not been placed on the official sliding rules, although it has come into use to some extent privately. It has also been applied, by its highly talented inventor, to other numerous and important calculations, and it deserves to be generally known. Mr. Woolgar's account of the invention is as follows:—

"Notwithstanding the various expressions of the rules for finding the content of a cask, I find that they may all be brought into one general term, viz.: $C = (1 \div 3r) LB^3 (x + yg^3 + zg)$, wherein $r = 353.036$, the cylindrical inches in a gallon, $g = \frac{H}{B}$, and y and z co-efficients, the sum of which, together with x , is always equal to 3; and in the values given to these quantities, the real difference between the rules consists.

	x	y	z
1. Spheroidal form . . .	2	1	0
2. Parabolic spindle . . .	1.6	0.6	0.8
Young's variety . . .	1.4	0.6	1.0
Hutton's variety . . .	1.3	0.83	0.87
3. Parabolic conoidal . . .	1.5	1.5	0
4. Conical . . .	1	1	1

"We may adopt any values we please for x , y , z , (their sum remaining constant) that will give a content according best with the actual average of casks, and any person may easily obtain a rule of calculation corresponding with the average of 50 or 100 casks, which he may select as the foundation of the process, thus:—Find the value of g , and also of $3rC \div LB^3$ for each cask separately; then pursue the graphic method for the delineation of a regular curve, using the latter values as ordinates, and the former as abscissæ; the ordinates of the adjusted curves are afterwards to be analysed into the three terms which constitute the factor $(x + yg^3 + zg)$. These being obtained, the formula for graduating the line X upon a sliding rule is, $\log. \sqrt{[(3r \div yg^3) - (4yz - z^2) \div 4yg - z \div 2y]}$, g being the gauge point whose position is to be laid down."

To explain the foregoing formula, we may take a cask of certain dimensions, say, length 40, bung 32, head 24, and show how the principle can be applied to finding the content according to the different varieties.

$(1 \div 3r) LB^3 = 1 \div 1059.108 (= 353.036 \div 3) = .00944 \times 40960 (= 32^3 \times 40) = 38.66624$, a constant number for all the varieties. Then by applying $(x + yg^3 + zg)$ to these varieties we obtain:—

1. Spheroidal, $2 + .5625 (= .75^2 = H \div B) = 2.5625 \times 38.66624 = 99.08$ gals.
2. Parabolic sp. $1.6 + (.5625 \times .6) + (.75 \times .8) = 2.5375 \times 38.66624 = 98.11$ gals.
 Young's $1.4 + (.5625 \times .6) + .75 = 2.4875 \times 38.66624 = 96.18$ gals.
 Hutton's $1.3 + (.5625 \times .83) + (.75 \times .87) = 2.4193 \times 38.66624 = 93.54$ gals.
3. Par. conoid. $1.5 + (.5625 \times 1.5) = 2.8437 \times 38.66624 = 90.62$ gals.
4. Conical, $1 + (.5625) + .75 = 2.3125 \times 38.66624 = 89.41$ gals.

* EXAMPLES ON THE LINE X.

(15.) Let the length of a cask be 40 inches, its bung diameter 32, and its head diameter 24, required its content according to the different varieties?

A against the bung diameter on B; and the slider B being thus drawn out a little to the left, the right hand end of it at 1 (a single radius only being used) will cut the line X in the groove at a special gauge point, which must be reserved; then set this special gauge point on D against the length on C, and opposite the bung diameter on D, will be the content in gallons on C.

V. THE VARIETY LINES.*

The lines marked "Sphd.," for *spheroid*, and "2 var.," for *second variety*, are respectively divided into certain equal

Set 24 on A against 32 on B, and at the end of the radius, the slider B will cut the line X at 20.33 for a spheroidal cask or first variety, or the proper gauge points for the other varieties, if marked on the rule. Then,

As the gauge point $\left\{ \begin{array}{l} 20.33 \\ 20.43 \\ 20.93 \\ 21.26 \\ 21.4 \end{array} \right\}$ on D : 40 on C :: 32 on D : $\left\{ \begin{array}{l} 99 \text{ gals. 1st. variety} \\ 98 \text{ gals. 2nd. variety} \\ 93.5 \text{ gals. Hutton's var.} \\ 90.6 \text{ gals. 3rd. variety} \\ 89.5 \text{ gals. 4th. variety} \end{array} \right\}$ on C.

If the line X be not graduated on the sliding rule, the proper gauge point may be found as follows:—Divide the head by the bung diameter, (which can be readily done on the lines A and B,) and under or over the quotient in the following diagram will be found the gauge point applicable to the particular variety of the cask, and to be used on the lines C and D according to the foregoing examples.

Quot. $\frac{H}{B}$		1.00	.95	.90	.85	.80	.75	.70	.65	.60
Gauge points for	Spheroid	19.0	19.3	20.0	20.5	21.0				
	1st. var.	19.0	19.5	20.0	20.5	21.0				
	Hut. var.	19.0	19.5	20.0	20.5	21.0	21.5	22.0		
	3rd. var.	19.0	19.5	20.0	20.5	21.0	21.5	22.0	22.5	
	4th. var.	19.0	19.5	20.0	20.5	21.0	21.5	22.0	22.5	23.0
Quot. $\frac{H}{B}$		1.00	.95	.90	.85	.80	.75	.70	.65	.60

* These lines are not much used at present, except the one marked "spheroid," which is applied by the officers of the revenue in cask gauging. These officers always consider casks to be of a spheroidal form; and if they are not in that form, an allowance or deduction is made in the length to reduce them to it. A mean is then found between the head and bung

distances, laid down against a line of inches and tenths, for finding the mean diameters of casks of what are called the first and second varieties, for the purpose of reducing them to cylinders, the more easily to calculate their contents. The first of these lines is always graduated on the head rods used by the officers at the wharfs for gauging casks.

VI. THE ULLAGE LINES.*

The ullage lines are two lines marked "Seg. St." or "S S," signifying *segment standing*; and "Seg. Ly." or "S L," signifying *segment lying*. The line S S, is numbered from left to right, with 1, 2, 3, 4, 5, 6, 7, 8, and

diameters, and taking such mean as the diameter of an equivalent cylinder, the content of the cask is found by means of the circular gauge point on the lines C and D. The spheroidal line shows the proper number to be added to the difference between the head and bung diameter, to obtain the mean above referred to. On the *head rod*, it is used with a line of inches, so that when the head diameter is subtracted from that of the bung, the spheroidal line shows the proper number to be added to the head diameter to give the mean; and on the line of inches such mean is shown under the number found. The numbers on the spheroidal line are found as follows:—If the difference between the head and bung diameter is 6 inches or less, it is multiplied by .68; and if it exceeds 6 inches, by .7; the product gives the difference to be added to the head diameter. It is obvious that this gives only an approximation, but it is seldom far from the truth. (See *Mensuration*, articles *Frustums*, *Spheroids*, *Conoids*, *Spindles*, and *Casks*.)

* Mr. Shirtcliffe, in his *Gauging*, 1740, states that he could not ascertain by whom these ullaging lines were introduced into gauging, nor the manner in which they were laid down. The following directions for graduating them are from *Moss's Gauging*, pp. 34, 35. "Take a cask whose content is 100 gals. and the nearest in form to those which frequently occur in practice; then suppose the bung diameter or length (according to the position of the cask) divided into 100 equal parts which must be laid down on a moveable alider in a logarithmic manner. Draw out and carefully measure successively the quantities contained in the first, second, third, fourth, fifth, &c., of those equal divisions of the bung diameter (or length); then place the quantity contained in the first, in the two first, three first, four first, &c., of those equal divisions *exactly* against the numbers 1, 2, 3, 4, &c., respectively, on the alider; and so by proceeding in this manner we shall obtain the true quantity in such cask to every hundredth part of its bung diameter or length. And if either of these were supposed to be divided into any other number of equal parts (besides 100) and the quantities contained in the first, two first, three first, &c., of those equal parts, be placed exactly opposite the numbers 1, 2, 3, &c., respectively on the alider, we should thereby obtain a table of segments for a standing (or a lying) cask similar to the former. Whence the reason of finding what is called the *segment* is very evident, for it is only conceiving the bung diameter

continued on another line with 9, 10, 20, 30, &c., to 100 ; and being placed on the rule so as to work with the slider B or C, is used for finding the ullage of a standing cask, or the quantity of liquor it contains when it is not full. The line S L is numbered in a manner nearly similar, and is graduated on "Head Rods" for ullaging lying casks.

*To ullage a cask.**—Set the length or bung diameter on B or C, to 100 on A, and against the wet inches on B or C, is a number upon SS or S L (according as the cask is standing or lying) to be reserved ; then set 100 on B to this reserved number on A ; and opposite the content on B will be found the ullage on A.

(or length) of that cask from which the lines of segments were supposed to be constructed to be divided into as many equal parts as there are inches, &c., in the bung diameter (or length) of the cask whose ullage we are then seeking, and placing that number against 100 on the segments ; then opposite any proposed number of wet inches, &c., or equal parts of the bung diameter (or length), we shall have the segment sought." On some of the old rules the slider used with the segment lines was marked "N."

* EXAMPLES IN ULLAGING.

(16.) Suppose the length of a standing cask to be 40 inches, the wet inches 10, and the content 92 gallons, what is the ullage or content of the wet inches ?

SS | 100 23 to be reserved.

B | 40 10

A | 23 21.2 gals. ullage.

B | 100 92

(17.) Suppose the bung diameter of a lying cask to be 33 inches, the wet inches 22 and the content 120 gallons, what is the ullage ?

SL | 100 72.4 to be reserved.

B | 33 22

A | 72.4 87 gals. ullage.

B | 100 120

(See further Mensuration, art. *Casks*.)

CHAPTER III.

MENSURATION OF SUPERFICIES.

MENSURATION* comprehends those branches of Mathematics which have for their object the comparison of geometrical quantities, and the determination of their proportions to each other. In a limited sense, it is applied to a system of rules and methods by which numerical measures of magnitude are obtained; and in this sense, it is usually called *Practical Geometry*.

The mensuration of *lines*† is nothing more than the means of ascertaining distances by lineal measure. When a line is accessible all the way, it is readily measured by means of a measuring rule, rod, tape or chain, divided into

* As Arithmetic teaches the knowledge of whatever can be expressed in numbers, Geometry teaches the knowledge of whatever is extended, and can be expressed in form and shape. The various kinds of magnitude which admit of measurement are:—(1.) Lines and Angles; (2.) Superficies; and, (3.) Solids. A *Line* has one dimension—length without breadth; its bounds or extremes being points. A *Surface* or Superficies has two dimensions—length and breadth; its bounds or extremes being lines. And a *Solid* has three dimensions—length, breadth, and thickness; its bounds or extremes being Superficies.

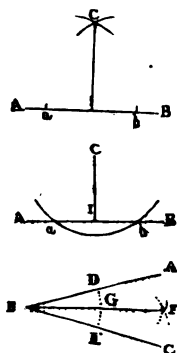
† A *Right line* is that which lies evenly between two points; a *Curved line* continually changes its direction between its extreme points; a *Perpendicular line* is one which, meeting another line, does not incline more to the one end of it than the other; and *Parallel lines* are straight lines in a plane which never meet, though extended ever so far both ways. An *Angle* is formed by the inclination of two right lines meeting each other in a point. When a line is perpendicular to another, making the angles on both sides equal, such angles are called *Right Angles*. When the angle is not a right angle, it is *Oblique*, and if greater than a right angle it is called an *Obtuse* angle; when less, it is an *Acute* angle. The *magnitude* of an angle does not depend upon the length of the lines by which it is contained, but upon the opening between

inches, feet, &c. When the length is short, or when it is necessary to represent the figure to be measured on a reduced scale on paper, a plain scale or diagonal scale* is used for that purpose.

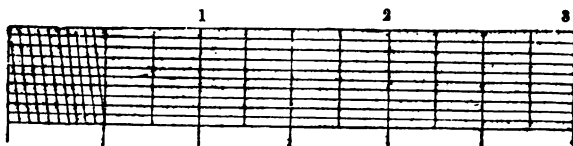
Mensuration of *Superficies*, or Plane Geometry, is the art of measuring plane or curved surfaces.†

The mensuration of a plane figure or other surface con-

such lines; that is, the extent (calculated in degrees, &c.), to which the branches are separated the one from the other; a whole circle being considered as divided into 360 degrees, and a right angle, therefore, being equal to 90, and so in proportion. *To draw a perpendicular upon a given line.*—From a given point on a line, as A B, set off an equal distance on each side, as s d , from which, as centres, with any radius greater than half s d , describe arcs cutting each other in C. Draw a line from C to the given point in A B; you will thus obtain two right angles and the perpendicular required. *To let fall a perpendicular from a given point on a given line.*—From the point, as C, take any radius extending beyond the given line, A B, and describe an arc cutting it in a b ; bisect s d in I, and join C I by a straight line, which is the perpendicular required. *To bisect an angle.*—From B, as a centre, with any radius, describe the arc D E, which divide into two parts; or from D E, with any radius, draw arcs cutting each other in F; join B F, or B G, and the angle will be bisected.



* The following is a scale of three inches, graduated into portions of quarter and half-inches, one of the half-inches being marked diagonally for the more accurate measurement of short distances. From this or any other graduated scale a measure of any length may be made upon a rod or tape, by marking a sufficient number of graduations.



The Officer's gauging rod and gauging tape for measuring utensils, malt, soap, &c., are graduated to inches and tenths, so as to be used decimally.

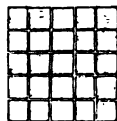
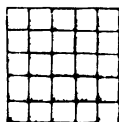
† A *Plane* or *Plane Surface* is that which is every where flat and even; and a *Curved Surface* is that which will not coincide with a straight line. A superficies may be contained within one curved line, but cannot be contained within fewer than three straight lines. The *Base* of a figure is the side on which it is supposed to stand erect. The *Altitude* is the perpendicular height from the base to the highest part. A line connecting two opposite angles of any quadrilateral figure is called a *Diagonal*; and a line bisecting any curved figure is called a *Diameter*.

sists in ascertaining the quantity of space contained within its boundaries, technically called finding its area. This area is computed from another space of a determinate form and magnitude, that is, from a *square*, whose side is one inch, one foot, &c., called the *measuring unit*. The dimensions are taken in lineal measure, usually in inches and parts of an inch (as tenths or eighths), and are reduced to square inches, square feet, &c., according to the nature of the thing measured; and the number of such square inches, feet, &c., contained in the figure is called the *area* of the figure.*

The area of a superficies, properly speaking, is the magnitude of its surface without regard to depth or thickness; but as most plane surfaces are measured with reference to some solid body of which they form a part, it is usual in excise calculations, to take the dimensions as if they were *one inch deep*, because the divisors for reducing them to gallons, bushels, &c., are in this denomination. This is in anticipation of the mensuration of solids; for the inches thus taken, are, in fact, *solid* or *cubic inches*; but this mode of calculation materially facilitates the reduction of the area into the proper number of gallons, bushels, &c.,

* This will be easily understood by supposing a piece of paper, of the form in the margin, is 5 inches long and 5 inches wide; it is obvious, from the figure, that it may be cut into 25 square inches; for, if we cut a slip an inch wide from any side of it, and divide it into five equal parts, each part will be an inch long, and an inch wide; that is, each of these will be a square inch. But the whole paper may be cut into as many such slips as it is inches in breadth; this piece of paper, therefore, may be cut into five such slips, and each slip will contain 5 square inches; thus, the whole will be cut into five times five, or 25 square inches—that is, to adopt the more usual terms, the area or content of the paper will be 25 square inches. This area is obviously found by multiplying the number of square inches in each slip by the number of slips; or, in other words, by multiplying the inches which the paper measures in length by the inches it measures in breadth. But, in this case when the length and breadth are equal, the content must be found by multiplying the number of inches in either side by itself.

—*Taylor's Sequel.*



contained in any utensil of which the plane figure may form a part. When, therefore, the *area* of any figure is mentioned in the present treatise, it will be understood to signify the content in *cubic inches*, unless otherwise expressed.

After the area has been found in inches, it is reduced into gallons, bushels, &c., either by dividing it by the number of square inches contained in those measures, as 277·274 for gallons, and 2218·192 for bushels; or by multiplying by the proper *factors*, as ·003606 for gallons; or ·000451 for bushels, &c.; and, in many instances, the gallons, bushels, &c., are found at one operation, without reducing the area into inches.

The figures which are usually the subject of mensuration of superficies are *rectilinear* (that is, such as are bounded by straight lines only), including Parallelograms, Triangles, Trapezoids, Trapeziums, and Irregular and Regular Polygons; or *curved*, (that is, such as are bounded by curved lines), including the Circle and its Segments and Sectors, the Ellipsis, the Parabola, the Hyperbola, and Irregular Curves.

I. PARALLELOGRAMS.*

A *Parallelogram* is a superficies bounded by four straight parallel lines. A right-angled parallelogram, having all its

* The square is of great importance in Mathematics, and it is the form to which, in the measurement of surfaces, as already stated, all other forms are reduced. The side of a square is equal to the square root of its area, and its diagonal is equal to the square root of twice its area. All parallelograms upon the same base and between the same parallels are equal to each other. The perpendicular breadth of any parallelogram is equal to its area divided by its length; and the length is equal to the area divided by the breadth. If the area of any rectangle be divided by one of its sides, the quotient will be the adjacent side; and if the square root of the sum of the squares of any two adjacent sides be extracted, the root will be the diagonal.

Various methods have been suggested for ascertaining the area in gallons and bushels without first finding it in inches, so as to save the trouble of using the long divisors 277·274 and 2218·192. One of these is by using *FACTORS* instead of divisors, as explained in p. 29; another is by the *SLIDING RULE*, as explained in p. 62; and another is by a *TABLE OF SEMISQUARES*, which is founded on the following principles:—It is well known that the area of every square is the square of one of its sides; and therefore, if the dimensions of one of the sides of a square be taken in inches and reduced to gallons or bushels, and then multiplied into

sides equal, is a *Square*; and if its opposite sides only be equal, it is a *Rectangle*. If all the sides of a Parallelogram be equal, but its angles not right angles, it is a *Rhombus*; and if the opposite sides be equal, but the angles not right angles, it is a *Rhomboid*.

To find the area.—Multiply the length by the breadth,*

itself, the area will be found in the denomination to which the dimensions were reduced. It is also known, that the area of any other rectangular figure is equal to half the united areas of the squares of its longer and shorter sides, diminished by half the area of a square, whose side represents the difference between such longer and shorter sides. It has therefore been considered, that if we take the areas of semisquares of different dimensions, and after reducing them to gallons and bushels, embody them in a table, we may ascertain the area of any rectangular figure by a very short process. We have only to add the tabular areas, answering to the two sides, and deduct from the amount the tabular area answering to the difference between the two sides, to obtain the area of the rectangle. This has been done in the Table of Semisquares referred to, which was invented by Mr. Todd, Officer of Excise, and printed at the Government press, and a considerable portion of which is inserted in the Appendix, No. 38. This Table is applicable to *gallons*, each area having been obtained by multiplying the side (represented by the figure in the margin), into itself, and dividing the product by 277·274, and taking one half for the tabular number or semisquare. It is calculated for inches and tenths as far as 100, and for inches only when the number exceeds 100. Should there be tenths in any number exceeding 100, the proportional part for such tenths may be found correctly as far as the third place of decimals by multiplying the difference, answering to the next greater and the next less number, by the given number of tenths. If any area be required in *bushels*, the area found as above must be divided by 8. Another mode of shortening the operation referred to, is to form a Table of mean proportionals between the sides of figures of various dimensions, marking one side at the top of the Table, and the other in the margin; then, by looking at the column where the sides intersect, a mean proportional will be found; and opposite to the number representing such mean proportional in the Table of Semisquares, will be found an area the double of which is the proper area sought. But a more concise method still, and one that is now for the first time suggested, is to form a TABLE of the SQUARES of different mean proportionals, reduced to the proper area in bushels; so that it is only necessary to look for the figures representing the two sides of any given figure, and in the column where they intersect will be found the area in bushels without any farther calculation. A specimen page of a Table of this description is given in the Appendix, No. 39. The areas in this Table are found by multiplying the two sides together and dividing by 2218·192. And the officer is strongly recommended to continue the calculations, so as to apply them to the usual dimensions of his malt floors and utensils, and to copy them on an enlarged scale for constant reference. He will find this a most effectual check upon the operations on the Sliding Rule.

* EXAMPLES.

- (1.) Required the area of a square whose side is 22 inches†

$$22 \times 22 = 484 \text{ inches. Ans.}$$

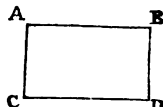
In the case of a square this is, in reality, only multiplying one of its sides into itself.

or perpendicular height; the product is the area in the denomination in which the dimensions were taken.

(2.) What is the area of a rectangle, the length A B being 18 inches, and breadth B D 9 inches?

$$18 \times 9 = 162. \text{ Ans.}$$

The same result is obtained by finding a mean proportional between the length and breadth and then squaring it, an operation which is readily performed on the Sliding Rule. (See p. 64.)



(3.) What is the area in gallons, bushels, and pounds weight of common hard soap (hot) of a rectangle, the length being 45 inches, and breadth 15 inches?

$$45 \times 15 = 675; \text{ then } 675 \div \begin{Bmatrix} 277 \cdot 274 \\ 2218 \cdot 192 \\ 28 \end{Bmatrix} = \begin{Bmatrix} 2 \cdot 4344 \text{ gallons} \\ \cdot 3043 \text{ bushels} \\ 24 \cdot 107 \text{ lbs.} \end{Bmatrix} \text{ Ans.}$$

Or, by *Factors*, (see p. 29,) thus:—

$$45 \times 15 = 675; \text{ then } 675 \times \begin{Bmatrix} \cdot 0036065 \\ \cdot 0004508 \\ \cdot 0357 \end{Bmatrix} = \begin{Bmatrix} 2 \cdot 4344 \text{ gallons.} \\ \cdot 3043 \text{ bushels.} \\ 24 \cdot 0975 \text{ lbs.} \end{Bmatrix}$$

Or, by the *Sliding Rule*, thus:—

$$\text{By divisors } \begin{Bmatrix} 277 \cdot 274 \\ 2218 \cdot 192 \\ 28 \end{Bmatrix} \text{ on A : 45 on B :: 15 on A : } \begin{Bmatrix} 2 \cdot 4 \text{ gallons.} \\ \cdot 3 \text{ bushels.} \\ 24 \cdot 1 \text{ lbs.} \end{Bmatrix} \text{ on B.}$$

$$\text{By a mean proportional } \begin{Bmatrix} 15 \text{ on C : 15 on D :: 45 on C : 26 on D, the mean proportional.} \\ 16 \cdot 65 \\ 47 \cdot 10 \text{ M S } \end{Bmatrix} \text{ on D : 1 on C :: 26 on D : } \begin{Bmatrix} 2 \cdot 4 \\ \cdot 3 \\ 24 \cdot 1 \end{Bmatrix} \text{ on C.}$$

$$\text{By the line } \begin{Bmatrix} 8 \\ 1 \\ 79 \cdot 2 \end{Bmatrix} \text{ on M D : 45 on B :: 15 on A : } \begin{Bmatrix} 2 \cdot 4 \text{ gallons.} \\ \cdot 3 \text{ bushels.} \\ 24 \cdot 1 \text{ lbs.} \end{Bmatrix} \text{ on B.}$$

Or, by the *Table of Semisquares*, (No. 38,) thus:—

$$\text{Tabular area for the length } \dots \dots \dots 45 = 3 \cdot 6516$$

$$\text{Ditto for the breadth } \dots \dots \dots 15 = \cdot 4057$$

$$4 \cdot 0573$$

$$\text{Ditto for the difference. } \dots \dots \dots 30 = 1 \cdot 6229$$

$$2 \cdot 4344 \text{ area in gallons.}$$

To find the area in bushels divide the area in gallons by 8, here = $\cdot 3043$; and to find the area in lbs. of common hard soap (hot) multiply such area by $9 \cdot 9 = 24 \cdot 1$ lbs.

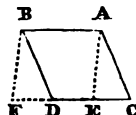
The area being calculated as if it were one inch deep, it is easy to understand, that if this parallelogram, or indeed any plane surface, be considered as representing the base of a rectangular vessel, we have only to ascertain how many inches the vessel is deep, and to multiply the area found as above by the depth in inches, to obtain the solid content of the vessel. And in many cases this can be done on the Sliding Rule at one operation.—See *Mensuration of Solids, infra*.

(4.) Let the sides of the rhombus A B D C = 40 inches = A B = B D, and the perpendicular B F 37 inches, what is its area in inches and gallons respectively?

$$40 \times 37 = 1480 \text{ inches and } 1480 \div 277 \cdot 274 = 5 \cdot 34 \text{ gallons.}$$

By the *Sliding Rule*.

$$277 \cdot 274 \text{ I M G, on A : 40 on B :: 37 on A : } 5 \cdot 34 \text{ on B.}$$



II. TRIANGLES.

A *Triangle** is a figure bounded by three lines. If all the lines be equal, it is called an *Equilateral* Triangle. If two of the lines be equal, it is called an *Isosceles* Triangle. And if all the sides be unequal, it is said to be a *Scalene* Triangle. A triangle is *Right-angled* when two of the sides are perpendicular to each other, and *Obtuse-angled* or *Acute-angled*, according as it has one of its angles obtuse, or one of them acute.

To find the area, I.†—Multiply the base by the perpendicular height, and half the product will be the area. Or,

(5.) Let the base of a rhomboid BC be 73·6, and perpendicular height AE 56·2; required the area in inches and bushels!

$$73\cdot6 \times 56\cdot2 = 4136\cdot32 \text{ inches,}$$

$$\text{and } 4136\cdot32 \div 2218\cdot192 = 1\cdot865 \text{ bushels.}$$

By the Sliding Rule.

1 on MD : 73·6 on B : 56·2 on A : 1·865 on B. Ans.

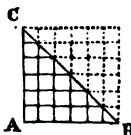
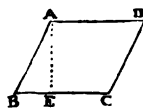
* A Triangle is formed by a line connecting the legs or extremities of an Angle, and has therefore three sides and three angles. In a right-angled triangle, the lower line is usually called the *base*, the upright line the *perpendicular*, and the other line the *hypotenuse*. The triangle is the most important figure in geometry, and its various lines bear the most interesting relation to each other. A circle being divided into 360 degrees, the sum of the angles of every triangle is equal to 180 degrees, that is, to two right angles. Every triangle is equal to half the parallelogram of the same base and altitude. The sides of different triangles, having equal angles, are proportional to each other; and the areas of similar triangles are to one another as the squares of their corresponding sides. The triangle is easily measured, and as all figures may be reduced to triangles, the principle upon which the measurement is founded (namely, TRIGONOMETRY), is applied to most of the problems in Astronomy, Geography, and Surveying. To find the base of a triangle, divide the area by half the perpendicular height. To find the perpendicular height, divide the area by half the base; or if it be an equilateral triangle, multiply the base by ·8660254. And to find the side of an equilateral triangle, divide the area by ·433, and find the square root of the quotient.

† EXAMPLES APPLICABLE TO RULE I.

(1.) Required the area of a triangle ABC, the base AB being 6 inches and the perpendicular AC being also 6 inches?

$$6 \times 6 \div 2 = 18 \text{ inches. Ans.}$$

The triangle is here obviously the half of a square, the whole of which would cut into 36 square inches, supposing each of the small squares to represent one square inch; half of this, therefore, constitutes the area of the triangle (p. 75).



multiply the base by half the perpendicular, or the perpendicular by half the base; the product in either case will be the area.

II.*—If the perpendicular is not known, subtract each side separately from half the sum of the three sides; multiply the half sum and the three remainders continually together, and the square root of the product will be the area.

(2.) Required the area in gallons and bushels of a triangle, the base being 396, and the perpendicular 174 inches?

$$396 \times 174 \div 2 = 34452. \text{ And } 34452 \div 277 \cdot 274 = 124 \cdot 252 \text{ gallons. And } 34452 \div 2218 \cdot 192 = 15 \cdot 58 \text{ bushels. Ans.}$$

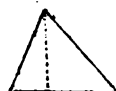
By the Sliding Rule.

$$\left. \begin{matrix} 1 \\ 8 \end{matrix} \right\} \text{ on MD : 396 on B :: } (174 \div 2) \text{ 87 on A : } \left\{ \begin{matrix} 15 \cdot 5 \text{ bushels} \\ 124 \cdot 25 \text{ gallons} \end{matrix} \right\} \text{ on B.}$$

This question may also be answered by the line A B, or by factors or tables, as in p. 78. In using the Table of Semisquares for this purpose, take *half* the perpendicular height for one of the sides, and the operation is the same as in parallelograms.

(3.) Required the area of a triangle, the base being 60 inches, and the perpendicular height 23·5?

$$23 \cdot 5 \times 60 \left(\frac{1}{2} \text{ base} \right) = 705 \text{ inches. Ans.}$$



* EXAMPLES APPLICABLE TO RULE II.

(4.) Required the area of a triangle, the length of the sides being 40, 28, and 32, respectively?

$$\frac{1}{2}(40 + 28 + 32) = 50; \left\{ \begin{matrix} 50 - 28 = 22 \\ 50 - 32 = 18 \\ 50 - 40 = 10 \end{matrix} \right\} \text{ the three remainders.}$$

Then, $50 \times 22 \times 18 \times 10 = 198000$, whereof the square root is 445 inches nearly, the area required.



This rule is useful where a perpendicular cannot be obtained. See Trapeziums, p. 81.

If the triangle be equilateral, the area will be found by multiplying one fourth of the square of a side by the square root of 3; or, which is the same thing, by multiplying the square of a side by ·433, or, more correctly, by ·4330127.

Or, square the side, and from this square deduct its fourth part; then multiply the remainder by the fourth part of the square of the side, and the square root of the product will give the area. Thus:—

(5.) Each side of the base of a triangular vessel measures 4 inches; what is its area?

$$4^2 = 16; \text{ then } 16 \div 4 = 4; \text{ and } 16 - 4 = 12.$$

$$\text{Then } 12 \times 4 = 48, \text{ and } \sqrt{48} = 6 \cdot 928 \text{ inches, area.}$$

If the triangle be isosceles, the area may be found by multiplying the sum of one of the equal sides and half the third side by their difference, and the square root of the product by half the third side; the result will be the area.

III. TRAPEZOIDS AND TRAPEZIUMS.*

A *Trapezoid* is a quadrilateral figure having two of its sides parallel but not equal. A *Trapezium* is a quadrilateral figure having none of its sides parallel.

To find the area of a trapezoid.†—Multiply the sum of the two parallel sides by the perpendicular distance between them, and half the product is the area.

To find the area of a trapezium.‡—Draw a diagonal from one of the angles to its opposite, and let fall perpendiculars from each of the other angles upon the diagonal. Multiply the sum of the two perpendiculars by the diagonal, and half the product will be the area.

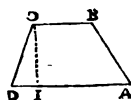
* A Trapezoid is equal in area to the product of its altitude by half the sum of its parallel sides; and the perpendicular distance between its two parallel sides may be found by dividing the area by half their sum. By drawing a diagonal from two of the opposite angles of a Trapezoid or Trapezium, or indeed any quadrilateral figure, it will be divided into two triangles.

† EXAMPLE OF A TRAPEZOID.

(1.) Let A B C D be a Trapezoid, one of the parallel sides, A D being 40, and the other, B C, 30, and the perpendicular distance between them 102; what is the area in inches and bushels, respectively?

$(40 + 30 =) 70 \times 102 = 7140 \div 2 = 3570$, area in inches.

Then, $3570 \div 2218.192$ (or $\times .000451$) = 1.61, area in bushels.



By the Sliding Rule.

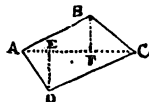
1 on MD : $(70 \div 2 =) 35$ on B :: 102 on A : 1.6 on B Ans.

‡ EXAMPLE OF A TRAPEZIUM.

(2.) Let A B C D represent a Trapezium whose diagonal A C is 60 inches, perpendiculars B F, 15, and D E, 27; required the area in inches and gallons?

$15 + 27 = 42$, and $42 \times 60 \div 2 = 1260$ inches.

Then, $1260 \div 277.274$ (or $\times .003606$) = 4.544 gallons.



By the Sliding Rule.

277.274 (IM G) on A : $(42 \div 2 =) 21$ on B :: 60 on A : 4.5 on B.

This is, in effect, the same as if the trapezium consisted of two triangles, and the area of each triangle was found and added together. When perpendiculars cannot be taken, the trapezium must be divided into two triangles, and the areas found separately by Rule II., p. 80.

If the trapezium can be inscribed in a circle, the sum of its opposite angles will be equal to two right angles, and its area may be found by adding the four sides together, and from half the sum subtracting each side separately; the square root of the product of the four remainders will give the area of the trapezium.

IV. IRREGULAR POLYGONS.

Plane figures, having more than four sides, are generally called *Polygons*; and if their sides and angles are not all equal, they are called *Irregular Polygons*.

*To find the area.**—Reduce the figure by diagonals and perpendiculars to as many regular figures (as Squares, Triangles, Trapeziums, or Trapezoids), as may be most convenient, and add their several areas together; the sum will be the area of the whole figure.

V. REGULAR POLYGONS.

A *Regular Polygon* † is a plane figure having more than four sides, its sides and angles being all equal. A *Pentagon*

* EXAMPLE OF AN IRREGULAR POLYGON.

(1.) Required the area, in inches and gallons, of the irregular figure A B C D E F G, which can be divided into two trapeziums and a triangle, the following lines being given:—

A o = 9, G B = 29, C n = 11, G C = 28.4, F x = 14.5,

C y = 13, F D = 35, E z = 7.4.

Here $\frac{1}{2} (9 + 11) \times 29 = 290 = \text{area of trap. A B C G A}$

$\frac{1}{2} (13 + 7.4) \times 35 = 357 = \text{FC D E F}$

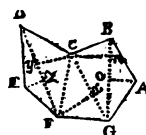
$28.4 \times 14.5 \div 2 = 205.9 = \text{tria. G F C}$

852.9 = area of the whole figure in inches.

And $852.9 \div 277.274$ (or $\times .003606$) = 3.076 gallons. Ans.

When any part of the figure is very irregular, or even bounded by a slight curve, it is usual in surveying, to erect a number of perpendiculars, as in the upper part of the annexed figure, adding the lengths together, and dividing the sum by their number for a mean breadth, and then multiplying such mean breadth by the length of the base. This will give the area of that part of the figure required, or nearly so. In excise calculations, however, irregular and doubtful curves, &c., are measured by equidistant ordinates, p. 93.

† A regular Polygon can always be inscribed in a circle, and all the angles of the inscribed figure are upon the circumference of the circle. The centre of a regular Polygon is a point equally distant from its sides or angular points; the *Apothem* is a perpendicular drawn from the centre to any one of its sides, and is analogous to the radius of a circle. The whole boundary of any figure is called its *Perimeter*; and the perimeter of a Polygon is, in fact, what the circumference is in a circle; for by it the figure is inclosed. Every regular Polygon, therefore, may be divided into as many triangles as it has



is a Polygon of five sides ; a *Hexagon* of six ; a *Heptagon* of seven ; an *Octagon* of eight ; a *Nonagon* of nine ; a *Decagon* of ten ; an *Undecagon* of eleven ; and a *Dodecagon* of twelve.

To find the area, I.* Add the sides together, and multiply half the sum by the perpendicular to the middle of one of the sides ; the product will be the area.

II.†—If the perpendicular be not known, multiply the square of one side of the Polygon by the area of a similar Polygon, the side of which is unity.

VI. CIRCLES.‡

A *Circle* is a plane figure bounded by a curved line called

sides, and as the area of a triangle is equal to half the product, produced by the multiplication of the base by the perpendicular, so the total amount of all the triangles forming a Polygon may be found by multiplying the sides of the Polygon, which are the bases of their respective triangles, by half the apothem ; because the apothem, as before explained, is only a perpendicular drawn from the centre of the Polygon to the middle of one of the sides, and is therefore equal to the perpendicular height of each triangle.

* EXAMPLE IN RULE I.

(1.) Let one of the sides of a hexagon, as FE, be 73 inches, then the perpendicular CH will be 62.85 ; what is its area ?

72×6 (No. of sides) $\times 62.85 \div 2 = 18467.60$ inches.

Here it will be seen that half $AB \times CH$ = the area of the triangle ACB ; and the figure contains as many such triangles as it has sides.



† EXAMPLE IN RULE II.

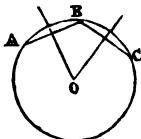
All regular polygons of the same number of sides are similar to each other ; and as similar figures are as the squares of their like sides, the square of the side of any polygon, multiplied by its area, when the side is unity, is equal to the area of the polygon. The area of a pentagon whose side is unity has been found to be 1.7204 ; of a hexagon 2.598 ; of a heptagon 3.6330 ; of an octagon 4.6224, &c. See Table No. 81, in the Appendix. The area of the above hexagon by this rule is as follows : $72 \times 72 = 5184$ and 5184×2.598 (Tabular number) = 18468.682 nearly, as before.

In the Table above referred to are the proper divisors and factors for finding the area in bushels or gallons at once. It will there be seen that the Tabular number for bushels for this figure is .0011713, which, being multiplied into 5184 the square of the side, is equal to 6.072 bushels.

‡ The Circle is one of those figures which are most used in the arts and in practical geometry, and, therefore, deserves particular attention. A circle is merely a polygon of an infinite number of sides, and can, within a given perimeter, inclose the largest possible space. Its perimeter or boundary is called its *Circumference*. Its *Diameter* is a right line drawn through its centre and terminating in its circumference on each side ; and any line drawn from the centre to the circumference is called a *Radius* or *Semidiameter*. A

the Circumference, which is every where equidistant from a certain point within it, called the centre.

Semicircle is equal to one half of a circle; and a *Quadrant* to one quarter. An *Arc* of a circle is any part of its periphery or circumference. The *Chord* or subtense of an arc is a right line joining the two extremities of such arc. The figure which is contained by an arc and its chord is called a *Segment*; and a figure contained by any arc and the radii drawn to its extremities is called a *Sector*. A *Sine* or *Right sine* of an arc is the line drawn perpendicularly from the arc to the diameter. The *Versed sine* is the part of the diameter intercepted between the arc and its sine. A *Tangent* is a line touching a circle without cutting it. *Concentric circles* are those which have the same centre; and the space included between their circumference is called a *Ring*. The space included by two parallel chords is called a *Circular zone*; and the space included between the intersecting arcs of two eccentric circles is called a *Lune*. To find the centre of a circle.—Take any three points A B C in the circumference and join A B and B C. Bisect A B and B C by perpendiculars meeting each other in the point O; then O is the centre required.



The rule for finding the area of a polygon (p. 83) leads to that for finding the area of a circle; because, as before observed, a circle may, by approximation, be considered as a regular polygon with an infinite number of infinitely small sides. As the area of a polygon is obtained by the multiplication of its perimeter by the half of its apothem; so it may naturally be inferred that the multiplication of the circumference of a circle by the half of its radius will produce the area of the circle. But here a difficulty arises; it is evident that the radius and circumference cannot be multiplied until the exact length of each be known. There is no difficulty of this kind in the measurement of polygons, because their sides, being straight lines, can easily be measured; the radius of a circle, being also a straight line, can be measured with equal facility; but how are we to ascertain the length of the circumference? or, in other words, what *ratio* does the circumference bear to the diameter? This question has occupied the attention of philosophers from age to age, and was never solved to the entire satisfaction of any till about a century ago. Archimedes, one of the Greek geometricians, who lived more than two thousand years ago, assigned the ratio to be as 7 to 22; nearer ratios have been discovered since his time, as 106 to 333, as 1702 to 5347, and as 113 to 355, &c. This last ratio is very useful for being turned into a decimal and for operations upon the sliding rule, and it agrees with the truth to the sixth figure inclusively. A Dutch mathematician carried the ratio to 36 figures, and this was at the time thought so important a discovery, that it was engraved on his tombstone at Leyden. Others subsequently extended the ratio still farther; and in a French work published about A.D. 1719, it was carried to no less than 128 figures. The ratio 1 to 3.1416 is sufficiently accurate for all common purposes; but when very great accuracy is required, 3.14159 may be used instead of it. Sometimes 3.141592653589793 is taken; but such a high degree of accuracy is seldom required. Taking then the diameter of a circle as 1, and its circumference, for the reasons above stated, at 3.1416, the area will be .7854, found as follows:

$$\begin{array}{rcl} \text{Circumference} & . & . & . & = 3.1416 \\ \text{Half radius } (= (1 \div 2) \div 2) & = & .25 \end{array}$$

$$\text{Area } .7854$$

Whatever the dimensions of a circle may be, it is evident that the circum-

There is no figure that affords a greater variety of useful properties than the Circle. It is the most capacious of all

ference must always bear the same ratio to the diameter; for a circle of any diameter (as half an inch, an inch, or two inches) is the exact representation of every other circle, of any magnitude whatever, from the head of a cask to the disc of the sun. Having therefore ascertained the area of a circle whose diameter is 1, we have only to use this area as a multiplier in order to ascertain the area of a circle of any other size. For the same reason, if we wish to find the area of any circle in gallons, bushels, or any other determinate measure, we have only to divide the *divisor* used for finding the area in these measures respectively by the foregoing factor .7854, and we thus obtain a divisor which will give the circular area instead of the square area; thus:—
 $277.274 \div .7854 = 353.036$, circular divisor for gallons.
 $2218.192 \div .7854 = 2824.287$, circular divisor for bushels.

In like manner, if we divide .7854 by the square *factors* we shall obtain proper circular *factors* for the same purposes; thus:—

$$.7854 \div 277.274 = .00283257, \text{ circular factor for gallons.}$$

$$.7854 \div 2218.192 = .00035407, \text{ circular factor for bushels.}$$

Again, if we extract the square root of the circular divisors we obtain *gauge points* for circular areas; thus:—

$$\sqrt{353.036} = 18.79, \text{ circular gauge point for gallons.}$$

$$\sqrt{2824.287} = 53.14, \text{ circular gauge point for bushels.}$$

Any circular gauge point may be converted into a square one, by multiplying such circular gauge point by the square root of .7854, which is .8863; and any square gauge point may be converted into a corresponding circular one by dividing the square gauge point by .8863. And so, if we divide the square divisors for gallons or bushels by .07958, the area of a circle whose circumference is 1, we obtain *divisors* for finding the areas in gallons or bushels from circumferences; viz. 3484.22 and 27873.72 respectively; or, if we divide .07958 by such square divisors, we obtain .000287, and .0000359, the respective *factors* for the same purpose; and the gauge points will, as in every other case, be the square roots of the new divisors. Again, if we divide the square divisor for bushels by the circular divisor for gallons or bushels we obtain *constant gauge points* for finding circular areas in gallons and bushels respectively, by the line M D upon the Sliding Rule (p. 67). See the Table of Divisors, Factors, and Gauge points, No. 30 in the Appendix.

To find the circumference of a circle, multiply the diameter by the above ratio of 3.1416; and to find the diameter, divide the circumference by the same ratio, or multiply it by .31831, the factor of 3.1416. To find the diameter of a circle, divide the area by .7854 and extract the square root; and to find the circumference, divide the area by .07958 and extract the square root. To find the diameter of a circle, equal in area to a given square, multiply a side of the square by 1.1283791; and to find the circumference of such a circle, multiply by 3.5449076. To find the *diameter* of a circle circumscribing a given square, multiply a side of the inscribed square by 1.4142136; and to find the circumference of such a circle, multiply by 4.4428934. To find the area of a *circular ring*, or the space included between two concentric circles, subtract the area of the smaller circle from that of the greater; the difference is the area of the circular ring. And to find the area of a *circular zone*, or the space included by two parallel chords, find the area of that part of the zone which forms a trapezoid (see p. 81), and the area of one of the segments at the end of the trapezoid (see p. 88); add the area of the trapezoid to twice the area of the segment; the sum is the area of the zone.

The three rules in the text for finding the area of a circle are applicable to the following circumstances: 1, when the circumference and diameter are

plane figures ; or contains the greatest area within the same perimeter ; or has the least perimeter about the same area.

To find the area, I.—Multiply the radius, or half the*

both given ; 2, when the diameter only is given ; 3, when the circumference only is given. The first rule is not much used in practice, because it is seldom that both dimensions can be obtained ; nor is this necessary, as the area can easily be calculated upon the foregoing principles from either the diameter or circumference. The readiest and the most common mode of measuring a circular figure is, to obtain its diameter by laying a rod or tape across the middle of its surface, and then applying the factor according to the second rule in the text, which gives the area with great facility. This calculation is well adapted to the sliding rule, on which the divisors, factors, and gauge points for the most usual measures are marked. In fact, the process of calculation is very commonly saved altogether by the use of a Table of Circular Areas, which gives the area from the diameter by inspection alone. The useful Table in the Appendix (No. 40) is a Table of Circular Areas of this description, calculated for any diameter, from 1 to 800 inches, and graduated for tenths of an inch. To find the area by this table, look for the diameter in the left hand column, and opposite to it is the area required. The third rule in the text is founded on the following calculation :—It has been seen that the circumference multiplied by the diameter and divided by 4 will give the area ; and as the diameter is equal to the circumference divided by 3·1416, the circumference multiplied by itself (that is, the square of the circumference), divided by 3·1416, and the quotient by 4, or divided at once by 12·5664 ($= 4 \times 3·1416$) will give the area. This rule is particularly applicable when a vessel is placed in such a position that its diameter cannot be obtained by actual admeasurement ; the area may then be obtained from the circumference, the proper divisors, factors, and gauge points for which will be found in the Table No. 30, in the Appendix. For facilitating these calculations, a specimen Table, No. 41, has been prepared, showing the areas of different circles in gallons, calculated from the circumference, and which can be used in the same manner as the table of circular areas calculated from the diameter above referred to. It has been constructed by multiplying the square of the circumference by ·000287 = ·07958 (the area of a circle in inches whose circumference is unity) ÷ 277·274 ; the quotient gives the tabular area in gallons. In using the table when there are odd tenths in the circumference, find the difference between the tabular area for the given whole number and the next higher tabular number, divide such difference by 10, multiply by the number of tenths given, and add the product to the first tabular area. The circumference of any circular vessel may be ascertained by a graduated tape, and if the tabular number applicable to each graduation were marked upon the tape, opposite to its corresponding number of inches, it is obvious that the area in gallons would be obtained by measurement alone. It would only be necessary in such a case to allow for the thickness of the vessel where the object was to obtain the internal area. (See Casks, *infra*.)

♦ EXAMPLE OF A CIRCLE BY RULE 1.

(1.) What is the area of a circle whose diameter is 42, and circumference 131·946 ?

$$131·946 \div 2 = 65·973 \text{ and } 42 \div 2 = 21$$

$$\text{Then, } 65·973 \times 21 = 1385·433. \text{ Ans.}$$

The circumference may be found from the diameter, or the diameter from the circumference, by the Sliding Rule, as follows :—3·1416 on A : 1 on B :: diameter on A : circumference on B. Or, 1 on B : 3·1416 on A :: circumference on B : diameter on A. When the rule is set in this way, the two lines form a series of proportional circumferences and diameters.

diameter, by half the circumference ; or, which is the same thing, multiply the circumference by the diameter, and take one-fourth of the product ; the product or quotient, as the case may be, is the area.

II.*—Multiply the square of the radius by 3.1416 ; or, the square of the diameter by .7854 ; the product in either case is the area.

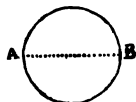
III.†—Multiply the square of the circumference by .07958, or divide it by 12.5664 ; the product or quotient, as the case may be, is the area.

* EXAMPLES OF A CIRCLE BY RULE II.

(2.) Let the diameter of a circle be 5, what is its area ?

$5 \times 5 = 25$, square of the diameter.

.7854, factor.



19.6350 Ans.

(3.) What is the area of a circle in gallons and bushels, the diameter being 42 inches ?

$42^2 \div 353.036 = 4.9966$ gallons. Ans.

$42^2 \div 2824.2879 = .6246$ bushels. Ans.

*By Factors. **

$42^2 \times .00283257$ (p. 85) = 4.9966 gallons. Ans.

$42^2 \times .00035407$ (p. 85) = .6246 bushels. Ans.

By the Sliding Rule.

By circular divisors (p. 58) $\left\{ \begin{array}{l} 353 \\ 2824 \end{array} \right\}$ on A : 42 on B :: 42 on A : $\left\{ \begin{array}{l} 5 \\ .62 \end{array} \right\}$ on B.

By gauge $\left\{ \begin{array}{l} 18.79 \text{ imp. g.} \\ 53.14 \end{array} \right\}$ on D : 1 on C :: 42 on D : $\left\{ \begin{array}{l} 5 \\ .62 \end{array} \right\}$ on C.

By the line $\left\{ \begin{array}{l} 6.28 \\ .7854 \end{array} \right\}$ on M D : 42 on B :: 42 on A : $\left\{ \begin{array}{l} 5 \\ .62 \end{array} \right\}$ on B.

By the Table of Circular Areas.

Opposite to 42, in Table No. 40, is the tabular area = 4.9966 gals. Ans.

Then, $4.9966 \div 8 = .6246$ bushels. Ans.

The area being calculated as if it were one inch deep, it is easy to understand that if this circle, or any other plane surface, be considered as representing the base of a circular vessel, we have only to ascertain how many inches the vessel is deep, and to multiply the area found as above by the depth found in inches to obtain the solid content of the vessel ; and in many cases this can be done at one operation on the Sliding Rule. (See *MENSURATION OF SOLIDS, infra*.)

† EXAMPLE APPLICABLE TO RULE III.

(4.) What is the area, in inches, gallons, and bushels respectively, of a circle, the circumference of which is 132 inches, corresponding with the last example in which the diameter is given ?

$132^2 \times .07958 = 1366.6$ inches ; and $132^2 \times .000287$ (p. 85) = 5 gallons ;

and $132^2 \times .000359 = .625$ bushels, as before, nearly.

By the Sliding Rule.

As $\left\{ \begin{array}{l} 59 \\ 167 \end{array} \right\} = \left\{ \begin{array}{l} \sqrt{8484.22} \\ \sqrt{27873.72} \end{array} \right\}$ on D : 1 on C :: 132 on D : $\left\{ \begin{array}{l} 5 \\ .62 \end{array} \right\}$ on C.

VII. CIRCULAR SECTORS AND SEGMENTS.*

A *Sector* is any part of a circle which extends from the circumference to the centre. A *Segment* is a portion of a circle cut off by a straight line drawn across it.

To find the area of a sector.†—Multiply the radius by half the length of the arc of the sector; the product is the area.

To find the area of a segment.‡—Find the area of a

By the Table of Areas of Circumferences.

Opposite to 132, in Table No. 41, is the tabular area = 5.0007 gallons;

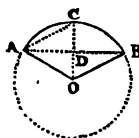
Then $5.0007 \div 8 = .625$ bushels. Ans.

* For a definition of the lines connected with Sectors and Segments, see note, p. 84.

† EXAMPLES OF SECTORS.

(1.) Let ACBO be the sector of a circle, the radius AO measuring 17 inches, and the arc ACB 26; required the area?

$$17 \times (26 \div 2) = 13 = 221 \text{ inches. Ans.}$$

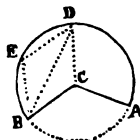


If the length of the arc of the sector be not known, it may be found as follows:—Multiply the radius of the circle by the number of degrees in the given arc, and that product by .01745329, the length of a degree of a circle whose radius is 1; the last product is the length required. Or, from eight times the chord of half the arc subtract the chord of the whole arc; one third of the remainder is the length of the arc nearly.

(2.) Let ADEBCA be a sector greater than a semicircle, the radius BC being 20.6, the chord BD of the arc BED 35.4, and the chord BE of half the arc 20.35962; required the area?

$$20.35962 \times 8 = 162.87696; \text{ and } 162.87696 - 35.4 \div 3 = 42.49232, \text{ length of the arc BED; } \textit{supra}.$$

$$\text{Then } 42.49232 \times 20.6 = 875.341792 \text{ Ans.}$$



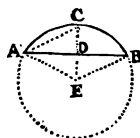
If the sector happen to be any known even part of a circle, the best mode is to find the area of the whole circle, and to take one half, one quarter, &c., for the answer.

If the degrees in the arc be known, the area may be found by the following proposition:—As 360° is to the degrees in the arc, so is the area of the whole circle to the area required.

‡ EXAMPLE OF SEGMENTS.

(3.) What is the area of the segment ACBDA, its chord AB being 24, and the radius AE or EC 20?

$$\begin{aligned} \sqrt{(A E^2 - A D^2)} &= \sqrt{(400 - 144)} = 16 = DE; \text{ E C } \\ - E D &= 20 - 16 = 4 = CD; \sqrt{(A D^2 + D C^2)} = \\ \sqrt{(144 + 16)} &= 12.64911 = AC; \text{ (see p. 76, and } \\ 1.47 \text{ Euclid); then, } (A C \times 8) - 24 \div 3 &= 25.7309 \\ \text{arc ACB; } \textit{supra}. \end{aligned}$$



sector, having the same arc as the segment; find the area of the triangle, formed by the chord of the segment and the two radii of the sector; then, if the segment be less than a semicircle, the difference of the two areas is the answer; if greater, their sum is the answer.

VIII. ELLIPSES.

An *Ellipsis** is a curved figure, bounded by a circumference, and described from two points in its longest diameter; it is a curve such as the planets are supposed to form in revolving about the sun.

And	12·8654 = half arc A C B	12 = A D
	20 = radius	16 = D E
	257·308 = area of sector E B C A	192 = area of triangle A B E.
	192 = area of triangle A B E	
	65·308 = area of segment A B C A.	

If the segment had been greater than a semicircle, the area of its corresponding sector would have to be found as in ex. (2), and the area of the triangle added to it; or the area of the smaller segment might be found as above, and deducted from the area of the whole circle; the remainder would give the area of the greater segment.

If the versed line, or height of the arc, as D C, and the chord be given, the remaining part of the diameter may be found by dividing the square of the chord of the whole arc by four times the versed sine. And the area of the segment may be found by multiplying the versed sine by ·626, adding to the square of the product the square of half the chord, and multiplying twice the square root of the sum by two thirds of the versed sine; the product will be the area. Or, divide the versed sine by the diameter, and find the quotient in the Table of Circular Segments, No. 33, in the Appendix; multiply the tabular number by the square of the diameter; the product is the area. In using this Table, if the quotient of the versed sine by the diameter be greater than ·5, subtract it from 1, and find the tabular area corresponding to the remainder, which subtract from ·7854, for the correct tabular area. If the quotient of the versed sine by the diameter does not terminate in three figures, and great accuracy is required, find the tab. area corresponding to the first three decimals, and subtract it from the next greater tab. area; multiply the remainder by the fractional part of the quotient after the three decimals, and add the product to the tab. area first found.

If, instead of being cut off by a straight line, the figure consist of the space included between the intersecting arcs of two eccentric circles, it is not called a segment, but a *LUNE*, and its area may be found as follows:—Find the areas of the two segments from which the lune is formed, and the difference will be the area required.

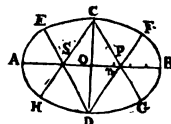
* An ellipse is produced from the section of a cone by a plane cutting both its sides but not parallel to the base. If two lines are drawn perpendicular to each other in an ellipse, and terminated both ways by the circumference, they are called the *transverse* and *conjugate* diameters or axes; the

*To find the area.**—Multiply half of the longest diameter by half of the shortest, and by 3·1416; or, multiply one of the diameters by the other, and by ·7854; or, multiply ·7854 by one diameter and the product by the other; the last product in either case is the area.

longer line being the transverse, and the shorter the conjugate. The two points from which the circumference is described are called the *foci*. When a straight line is drawn from any point in the circumference perpendicular to either of the diameters, it is called an *ordinate*.

To describe an Ellipsis, the two diameters being given.—

Draw the two diameters A B, C D; make A n equal to C D; divide the remaining part, n B, into three equal parts, and set off two of them, from O to S and from O to P; through S draw D S E and C S H, and through P draw D P F and C P G; with the radius A S, and centre S, describe the arc H A E, and with the radius P B, and centre P, describe the arc F B G; with D as a centre, and radius D C, describe the arc E F; and with C as a centre, and the same radius, C D, describe the arc H G, which will complete the ellipsis. Or, an ellipsis may be drawn by passing a string of a given length round two pins fixed in the foci, and then carrying a pencil round inside the string, always keeping it stretched as far as possible.



To find the Circumference of an Ellipsis.—Multiply the square root of half the sum of the squares of the two diameters by 3·1416; or multiply the sum of the two diameters by 1·5708; the product in either case is the circumference nearly. An ellipsis being to the circle what a parallelogram is to the square, the area of an ellipsis is a geometrical mean proportional between the area of two circles whose diameters are the transverse and conjugate diameters of the ellipsis. Hence the rule in the text. If it be required to find the area in gallons, bushels, &c., the product of the two diameters may be divided by the circular divisors, 353·036 for gallons, and 2824·29 for bushels; or multiplied by the proper circular factors, ·0028325 for gallons; or ·0003541 for bushels (See p. 85). Another method of ascertaining the area of an ellipsis is by means of the Table of Circular Areas, No. 40, in the Appendix, the rule for which is as follows:—From the tab. area answering to the sum of the transverse and conjugate diameters, subtract the area of their difference; one-fourth of the remainder will be the area in gallons. This is a very ready and a very accurate mode of finding these areas, and probably the best that has yet been suggested. Another method would be to find a mean proportional between the two diameters, and look for the tab. area in the above Table, which will give the result at one view. But a still more concise operation, when great accuracy is not required, is by the *Sliding Rule*. (See p. 67, &c.)

* EXAMPLES.

(1.) What is the area of an ellipsis whose transverse diameter is 24, and conjugate 18?

(1.) $12 \times 9 = 108$, and $108 \times 3\cdot1416 = 339\cdot2928$. Ans.

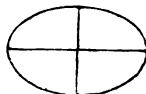
(2.) $24 \times 18 = 432$, and $432 \times \cdot7854 = 339\cdot2928$. Ans.

(3.) $\cdot7854 \times 24 = 18\cdot8496$, and $18\cdot8496 \times 18 = 339\cdot2928$. Ans.

(2.) What is the area in gallons and bushels of an ellipsis whose transverse diameter is 105·3 and conjugate diameter 55·8?

$105\cdot3 \times 55\cdot8 \div 353\cdot036$ (or $\times \cdot0028325$) = 16·6434 gallons area.

$105\cdot3 \times 55\cdot8 \div 2824\cdot29$ (or $\times \cdot0003541$) = 2·0804 bushels.



IX. PARABOLAS AND HYPERBOLAS.*

A *Parabola* is a curve supposed to be the line which would be described by a cannon ball; and a *Hyperbola* is a curve more open than the parabola. The branches or sides of these two figures are geometrically described as indefinite; but for the purposes of Mensuration, they are usually terminated by a straight line, or ordinate, joining them at the widest part.

To find the area of a parabola.†—Multiply the base

By the Sliding Rule.

By circular divisors $\left\{ \begin{smallmatrix} 353 \\ 2824 \end{smallmatrix} \right\}$ on A : 105·3 on B :: 55·8 on A : $\left\{ \begin{smallmatrix} 16·6 \\ 2·1 \end{smallmatrix} \right\}$ on B.
By finding a $\left\{ \begin{smallmatrix} 105·3 \text{ on C : } 105·3 \text{ on D :: } 55·8 \text{ on C : } 76·6 \text{ on D, mean prop.} \\ \text{mean pro- } 18·79 \\ \text{portional } 53·14 \end{smallmatrix} \right\}$ on D : 1 on C :: 76·6 on D : $\left\{ \begin{smallmatrix} 16·6 \\ 2·1 \end{smallmatrix} \right\}$ on C.
By the line M D $\left\{ \begin{smallmatrix} 6·28 \\ .7854 \end{smallmatrix} \right\}$ on M D : 105·3 on B :: 55·8 on A : $\left\{ \begin{smallmatrix} 16·6 \\ 2·1 \end{smallmatrix} \right\}$ on B.

By Table of Circular Areas.

Tab. area of $(105·3 + 55·8 =)$ 161·1 = 73·5142

Tab. area of $(105·3 - 55·8 =)$ 49·5 = 6·9405

4) 66·5737 (16·6434. Galls.

Then $16·6434 \div 8 = 2·0804$ bushels.

Or mean proportional of 105·3 and 55·8 = 76·6, tab. area = 16·6203 gals. Ans.

The area of an elliptical *segment* may be found as follows:—Divide the versed sine of the segment by that diameter of the ellipse of which it is a part, and find in the Table of Circular Segments, No. 33, a tabular number, corresponding with the quotient; multiply the number thus found, and the two diameters of the ellipse, continually together; the product is the area. Thus, to find the area of an elliptical segment, the versed sine being 20, and the diameter 70 and 50:—

$20 \div 70 = .285\bar{7}$. Then tab. number of $.285\bar{7} = .185166 \times 70 \times 50$
= 648·081 area.

The area of an elliptical *ring* or the space included between the circumference of two concentric and similar ellipses may be found, by subtracting the area of the less ellipse from the area of the greater.

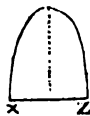
* A line drawn from the vertex or uppermost point of a parabola or hyperbola, so as to divide it into two equal parts, is called the *axis*. The point to which every part of the curve has a fixed relation is called the *focus*. Any line cutting the axis at right angles is called an *ordinate*. That part of the axis which is contained between the vertex and the ordinate is called the *abscissa*. Every parabola is two-thirds of its circumscribing parallelogram.

† EXAMPLE OF A PARABOLA.

(1.) What is the area of a parabola whose height is 12, and the base or double ordinate X Z 16?

$12 \times 16 = 192$, and $192 \times \frac{2}{3} = 128$. Ans.

The area of the *frustum* of a parabola (being that which remains after a part has been cut from the top by a line parallel to the base) may be ascertained as follows:—Find a third proportional



by the height, and two-thirds of the product is the area.

*To find the area of a hyperbola.**—Multiply the transverse by the abscissa; to the product add five-sevenths of the square of the abscissa, and multiply the square root of the sum by twenty-one; add four times the square root of the product of the transverse and abscissa to the product last found, and divide the sum by 75; divide four times the product of the conjugate and abscissa by the transverse, and this last quotient, multiplied by the former, will give the area required, nearly.

X. IRREGULAR AND DOUBTFUL CURVES.†

Most of the superficies that require measuring will come within one or other of the foregoing definitions; but as it

to the sum of the bases, and one of them, to which add the other base; the sum multiplied by two-thirds of the height is the area. Or, from the area of the whole parabola take the area of the upper segment, (taken as the segment of an ellipse, see p. 91,) the remainder will be the area of the frustum.

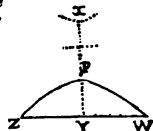
* EXAMPLE OF A HYPERBOLA.

(2.) What is the area of a hyperbola, the transverse axis XP being 30, the conjugate 18, and the abscissa or height PY 10?

$$(30 \times 10) + (10^2 \times \frac{5}{7}) = 371.43; \text{ then } \sqrt{371.43 \times 21} = 404.67$$

$$\text{Then } \sqrt{30 \times 10} = 800 = 17.32, \text{ and } 17.32 \times 4 + 404.67 = 473.95; \text{ then } 473.95 \div 75 = 6.32.$$

$$18 \times 10 \times 4 \div 30 = 24, \text{ and } 6.32 \times 24 = 151.68. \text{ Ans.}$$



† The general method of approximating the areas of curvilinear planes, by means of any given number of equidistant perpendicular ordinates or diameters, seems to have been first demonstrated by Sir Isaac Newton. It was early applied to the subject of gauging, and a rule was given for the use of the officers in *Shirtcliffe's Gauging*, which was afterwards improved by Farrar in the Appendix to *Overley's Gauging*. The general rule in the text was given and demonstrated at length in *Moss's Gauging*, (1779), and has ever since been acted upon by the officers of the revenue. In this rule, the curve is divided into portions by each pair of ordinates in the figure, and each portion is considered as the curve of a parabola, because a parabolic curve has an infinite variation of curvature, and may be considered to be coincident with any other curve for a small distance. The area of each portion of the curve may thus be obtained by the rule applicable to a parabola, and the area of the other part of the figure included within each pair of ordinates, as a quadrilateral; the area of the curve, however, is only an approximation, but it is evident that the shorter each portion of the curve is made, or, in other words, the greater number of ordinates are taken, the nearer we arrive at accuracy. For any

is sometimes difficult to ascertain to which definition a figure properly belongs, it is convenient to have a rule, by which any superficies can be measured without strictly defining its geometrical proportions. Such a rule has been accordingly laid down; and as, when accurately performed, it produces a very near approximation to the true measure, it has received the sanction of the Commissioners, and has been published by their authority.

This measurement is effected by means of what are called

right-lined figure, the rule would give the area exactly, and for any perfect figure such as a circle, parabola, &c., the approximation is very close; and for every other kind of figure, upon a large scale, it produces a result nearer accuracy than any other kind of measurement hitherto adopted.

The rule in the text is founded on the supposition that the area is to be found in inches. If it be required to be found in gallons, (which it usually is in practice,) instead of multiplying by one-third of the common distance of the ordinates, multiply by the entire common distance, and divide by 831·822, (three times the number of cubic inches in a gallon,) which will give the area in gallons. In like manner, in finding the area of the segments, instead of taking one-third of the product as the area, divide such product by the same divisor. Or, the two products may first be added together, and then divided by 831·822, which will give the area of the entire figure. For the mode of drawing the ordinates on the bottom of Distillery Vessels, and gauging and tabulating such vessels, see *MENSURATION OF SOLIDS, Art. Distillery Vessels (infra)*.

EXAMPLES.

(1.) Find, by equidistant ordinates, the area of a circle whose diameter is 36 inches.

If in the quadrant D O B, equidistant lines are drawn perpendicular to the diameter, their common distance being 4 inches; then by the property of the circle we get their lengths, namely, 8·24; 13·41; 16·12; 17·55; and O B 18.

Sum of the extreme ordinates	26·24
Four times the sum of the 2 ^d and 4 th (30·96)	123·84
Twice the middle ordinate (16·12)	32·24

182·32

which, being multiplied by one-third of the common distance, or (which is more convenient when the common distance will not divide,) multiplied by the common distance, (here 4,) and the product divided by 3, gives the area of the space O B e f.

243·093

Add the segment D e f, which (by reason of its smallness, with regard to the whole circle) differs but little from a semi-parabola, that is $\frac{2}{3} (8·24 \times 2)$.

10·980

Area of the quadrant D O B

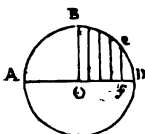
254·073

4

Area of the whole figure

1016·292

As the area of only one segment was to be found, the extreme ordinate was multiplied by its versed sine or height (2), and two-thirds of the product

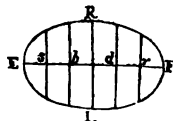


equidistant perpendicular ordinates; and although the rule more particularly applies to curved figures, there is scarcely any kind of superficies upon a large scale to which it may not be advantageously extended.

To find the area.—Draw any odd number of equidistant ordinates or lines across the figure, cutting the greatest diameter at right angles. Then, to the sum of the first and last, or the two extreme ordinates, add four times the sum of the second, fourth, sixth, and eighth, or even ordinates,

taken. The area of this circle, found by the common method, exceeds this calculation by $\frac{7}{12000}$ of a gallon; and by making use of a greater number of ordinates, the difference would have been less.

(2.) Required the area in inches and gallons of the curvilinear plane $ERFL E$, whose axis EF (bisected by RL) is 112 inches; the perpendicular ordinates, s 70, b 79, R L 80, the next 78·6, and r 69; the common distance, b s , &c. 24; and, therefore, E s , (or F r), 8.



Sum of the two extreme ordinates	139
Four times the sum of the 2 nd and 4 th	630·4
Double the sum of the rest (3 rd)	160
	929·4
Multiplied by $\frac{1}{3}$ of 24	8

Area of the parts contained between the extreme ordinates	7435·2
s 70 + r 69 = 139 $\times$ (twice E s =) 16 $\div$ 3	741·33 Segs. E s , F r

Total area in inches 8176·53

Then $8176·53 \times \cdot 003606 = 29·4845$ gallons. Ans.

(3.) What is the area of a curvilinear plane, the transverse diameter of which is 102 inches, and the perpendicular ordinates, (seven in number,) 54, 60, 62·2, 63 (the conjugate), 62·4, 60·1, 54·6; their common distance 15; and, therefore, the height of either segment at the end, 6?

Sum of the two extreme ordinates	108·6
Four times the sum of the 2 nd , 4 th , and 6 th	732·4
Twice the sum of the rest (3 rd and 5 th)	249·2
	1090·2
Multiply by $\frac{1}{3}$ of 15	5

Area of the part between the extreme ordinates	5451·0
108·6 (sum of extreme ordinates) $\times$ 12 (twice the height, or versed sine) $\div$ 3	434·4

The area of the whole figure 5885·4

“If the area of this figure be computed as an ellipse, it will be 3·63 gallons too little; whence it is manifest, that the revenue may be greatly injured by gauging all curvilinear vessels as ellipses.”—*Moss's Gauging*. The semi-ordi-

and also double the sum of the rest ; multiply the total by one-third of the common distance of the ordinates ; the product is the area of the space between the extreme ordinates ; to which must be added the areas of the segments at the ends, which are usually found by multiplying the sum of the extreme ordinates by twice the perpendicular height or versed sine of either segment ; one-third of the product is the area of the segments : the sum of these areas is the answer.

nate of an ellipse is always equal to the square root of the product of the two parts into which it divides the transverse diameter, multiplied by the quotient of the conjugate, divided by the transverse diameter ; hence, when the semi-ordinates, thus obtained, are greater than by actual admeasurement, the figure is less than an ellipse ; but when less, which is most frequently the case, the figure is greater than an ellipse. If the ordinates in the foregoing example had been 80·4, 40·5, 48·2, R L 63·0, 48·4, 40·2, 30·0, the area would be 4383·6 inches, showing a difference of 1501·8 inches by a difference in the ordinates alone, the transverse and conjugate diameters and the common distance remaining the same. If a figure of this description be measured as an ellipse, its area is nearly 3 gallons more than the true area.

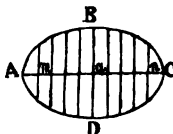
(4.) Find the area in gallons of the curvilinear space A B C D A, whose dimensions, obtained by actual admeasurement, are as follows ;—Axis A C (or twice A a) 151·7 inches, the perpendicular ordinates 61·4, 101·2, 118, 123·7, B D 125·2, 124, 118·6, 99·9, 57, their common distance 17; and therefore, A m, (or C n) 7·85.

Sum of the two extreme ordinates	118·4
Four times the sum of the even ordinates	1795·2
Twice the sum of all the rest	723·6
	2637·2
Common distance	17
	44832·4
118·4 (sum of extreme ordinates) × 15·7 (sum of their heights)	1858·68

831·822 [see p. 93]) 44832·4 (56·13

(5.) Find the area of a curvilinear plane by means of 13 ordinates, namely, 82·4, 96·5, 112, 119·2, 121·3, 122·4, conjugate 123, 122·6, 121·2, 118·9, 112, 96·3, 82·4; common distance 12, transverse 148, and height of each segment 2 inches.

Ans. 16409·33. (See *Moss's Gauging*, p. 257.)



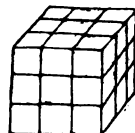
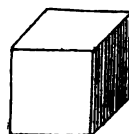
CHAPTER IV.

MENSURATION OF SOLIDS.*

A SOLID, or body, has three dimensions, length, breadth, and depth; and its mensuration consists in ascertaining its capacity or content. As in measuring *Surfaces*, the simplest plane figure, which is a *Square*, is taken for the measuring unit, so in measuring *Solids*, the simplest solid figure, which is a *Cube*, or figure bounded by six equal squares, is chosen for this purpose. When the length of one of the sides of the square is one inch, the entire solid is called a cubic inch; when a foot, a cubic foot, &c. And the whole of the mensuration of solids consists in finding how many cubic inches, cubic feet, &c., are contained in a solid of any particular form.†

* A solid may be conceived to be formed by the direct revolution of a superficies. As a plane or surface is bounded or terminated by lines, a solid or body is bounded by planes or surfaces. The investigation of the properties and relations of the various figures, assumed by such bodies, is the object of *solid geometry*.

† This will be easily understood if we suppose a piece to be sawn out of a tree of a square form, an inch long, an inch wide, and an inch thick; it would be what is called a *solid inch*, as in the margin; and the geometrical name of such a solid is a *cube*. Now, if we suppose a piece of timber of the form of a cube to be 3 inches long, 3 inches wide, and 3 inches thick; it is plain, from inspecting the figure, that it may be cut into 3 oblong pieces, each 3 inches wide, 3 inches long, and 1 inch thick. Each of these oblong pieces is a square of the side, and may be divided into 9 pieces, each 1 inch long, wide, and thick, or into 9 solid inches. But there are as many of these oblong pieces as there are inches in thickness; and, consequently, the whole cube may be divided into 9×3 , or 27 solid inches. The mensuration of solids is readily effected when the mensuration of superficies is fully understood. The simplest process is actual admeasurement; that is, dividing the given solid into a sufficient number of equal parts, each of which will exactly fill a measure which has been previously ascertained to hold just an inch, a



As a solid means either any body, or the space which such body fills, so the surface of any solid may mean either the external surface of the body, or the internal surface of the space which surrounds it. Hence in taking the dimensions of any body, it is of no importance whether they are taken internally or externally. Hence, also, it is evident that when a liquid or other substance is introduced into a vessel of the form of any particular solid figure, so as exactly to fill it, such substance will assume the form of the solid, and the measurement of the vessel as a solid will be the real measurement of the liquid or substance introduced, with the addition only of the thickness of the vessel, which must either be allowed for in taking the dimensions, or deducted from the contents when the operation is completed. Excise calculations are made in both these ways; and it will,

pound, a gallon, a bushel, &c.; and the number of parts or measures into which the solid is thus divided, is its *content* or *capacity* in inches, pounds, gallons, bushels, &c., according to the measure used. When the solid cannot be measured in this manner, the dimensions are taken in lineal measure (usually in inches), as in the case of Superficies, and such dimensions reduced into cubic inches, according to prescribed rules, and from thence, if necessary, into pounds, gallons, bushels, &c.; or, (when the operation is practicable), they are reduced at once from lineal inches into pounds, gallons, bushels, &c., as may be required. This has been partly anticipated in the mensuration of superficies, wherein, instead of taking surfaces as being of no depth or thickness, as in strictness they are not, they have been taken as if they were of the thickness of an inch; so that the calculations in each case gave at once the area of the superficies, and also the content of similar solid bodies, whose bases were one inch thick; and such area or content required only to be divided by the number of cubic inches contained in a gallon, bushel, pound, &c., to give the content in those denominations respectively. If, instead of one inch, the solid be two, or any number of inches thick or high, it is obvious that we have only to multiply the superficial area or content, found as above, by the number of inches which the solid is thick or high, to obtain the whole content of the solid. It will also be seen, that, in making the calculations for the mensuration of superficies, instead of finding the area in inches, in which the dimensions are taken, it was found, whenever practicable, in gallons, bushels, pounds, &c., by one operation. This is very convenient in reference to calculations connected with the Excise Duties, which are usually imposed in gallons, bushels, pounds, &c.; and the object of the Officer, therefore, is to arrive at those denominations respectively with as much facility as possible. For this purpose he should become familiar with the various methods for shortening the calculations by factors, tables, the Sliding Rule, &c., already explained, which are applicable equally to solids as to superficies; in addition to which many other compendious rules are given in the present Chapter.

therefore, be understood that the following rules for finding the contents of bodies usually apply as well to bodies that are absolutely solid, in the popular sense of the term, as to the contents or capacity of any vessel of the same form as the bodies in question; the difference being that, in the former case, the dimensions are supposed to be taken externally, and in the latter, internally.

Solids are sometimes divided into Regular and Irregular. The *Regular* solids are those which are terminated by regular and equal planes, including the Prism, the Pyramid, the Prismoid, the Wedge, the Sphere, the Spheroid, the Spindle, the Conoid, the five regular bodies, and the various parts and sections of these solids respectively. The *Irregular* solids are almost infinite, comprehending all such as do not come under the definition of regular solids. Those which are likely to come under the Officer's observation may be classed under the heads of Ungulas, Distillery Vats, Stills, Coppers, Casks, and Malt Floors.

I. PRISMS.*

A *Prism* is a solid with two ends or bases connected together by means of straight lines. The ends or bases may be plane figures of any form, but they are always equal, alike, and parallel to each other. They receive particular names according to the form of their bases, as a *Square Prism*, a *Triangular Prism*, a *Pentagonal Prism*, a *Hexagonal Prism*, &c. And hence the denomination "*Prism*" comprises also the *Cube* (which, as a hexagon, is considered

* PRISMS.

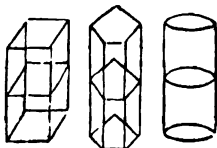
The generic name of *Prism* is given to all polyhedrons, or many-sided figures, contained between two parallel and equal polygons; and it may be considered as generated by the motion of one of its bases, of whatever form it may be, descending always parallel to itself along a right line. A *Cylinder* may be conceived to be generated by the revolution of a right-angled parallelogram, about one of its sides, which remains fixed. The *axis* of a prism is a line conceived to be drawn lengthwise through the middle of it, connecting

as one of the five regular bodies), and *Parallelopipedon*, the former being a square prism, and the latter a rectangular one. And even a *Cylinder* may be considered as a round prism, or one that has an infinite number of sides. A prism is likewise said to be *regular* or *irregular*, according as the figure of the base is a regular or an irregular polygon. A prism, again, is either *right* or *oblique*. A *right* prism is that whose sides and axes are perpendicular to its ends, like an upright tower; and a prism is *oblique* when the axis and sides are oblique to the ends, so that when set on one end it inclines more on one hand than the other.

A *Cube* is bounded or comprehended by six equal sides. A *Parallelopipedon* is bounded by six parallelograms, every opposite two of which are equal, similar, and parallel; and when the bounding parallelograms are right-angled and perpendicular to each other, it is called a *rectangular parallelopipedon*. A *Cylinder* has circular instead of rectilineal bases or ends, which are equal and parallel; and

the centre of one end with that of the other; and the *frustum* of a prism is any part thereof cut off parallel to the base.

The solidity of a prism is equal to the area of its base multiplied by its height; and the surface, or superficial area of a prism is the area of the two ends and of the sides added together. A *frustum* of a prism, (being a part cut off parallel with the base), is a prism, only of a less depth than the prism from which it was cut off, as is obvious from the figures. Therefore, as the



axis of the whole prism, is to any part of its axis, so is the content of the prism to the content of the frustum, or part cut off. Thus, if we want to cut 8 inches from the top of a cylinder, parallel to the base, the original depth being 24, and its content 17,280 inches, we have only to say, $24 : 8 :: 17,280 : 5760$ the solidity of the less frustum; and as $24 : 16 :: 17,280 : 11,520$ the solidity of the greater. Again, as the solidity of the whole cylinder is to the solidity of a frustum, or part cut off, so is the axis of the whole cylinder to the axis of the part cut off. Thus, if a cylinder be of the depth of 80 inches, its diameter 75, and its solid content, therefore, 1274·656 gallons, and if it be required to cut it parallel to the bottom at such a distance that it may contain 940 gallons, we say $1274·656 : 940 :: 80 : 58·99$ inches, the distance required; which may easily be proved by finding the depth or axis of the part cut off, the content of it being $1274·656 - 940 = 334·656$; then, as $940 : 334·656 :: 58·99 : 21·01$, the depth of the part cut off; which being added to 58·99, the depth of the remaining part, will give 80, the whole depth of the vessel before it was cut.

its diameter is of an equal thickness or length in all its parts.

To find the content of a prism.—Find the area of the*

* EXAMPLE OF A CUBE.

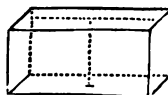
- (1.) If the side of a cube be 40 inches, what is its solidity?
 $40 \text{ (length)} \times 40 \text{ (breadth)} = 1600 \text{ area (see p. 77)}; \text{ then } 1600 \times 40 \text{ (depth)} = 64,000 \text{ inches, solid content.}$

EXAMPLES OF RECTANGULAR PRISMS.

- (2.) One of the sides of a square-bottomed vessel is 135 inches and its depth or height 40: what is the content?
 $135 \times 135 = 18,225 \text{ area (see p. 77)}, \text{ and } 18,225 \times 40 = 72,900 \text{ in. content.}$

MALT UTENSILS AND FLOORS.

- (3.) If a maltster's couch frame be 45 inches long, 15 broad, and 12 deep, what is its area and content respectively in bushels?



$45 \times 15 = 675 \div 2218.192 = .3043 \text{ bushels, area (p. 78)}; \text{ then } .3043 \times 12 = 3.6516 \text{ bushels content.}$

The area in this and all similar examples may be found by the use of factors, or by the Sliding Rule, or by the Table of Semisquares, or by a mean proportional, as shown in p. 78, and in any case requires only to be multiplied by the depth, as above, for the content; or the content may be found at one operation, as follows:—

By the Sliding Rule.

Length	Breadth	Depth	Content
45 on M D	15 on B	12 on A	3.65 on B.
Breadth	Depth	Length	Content.
Or, 15 on M D	12 on B	45 on A	3.65 on B.

The latter mode is, perhaps, the most convenient, but it is best to work by one mode as a check against the other.

A short method of finding the area of a rectangular body in bushels, and one that would be found useful as a check in operations upon the Sliding Rule, is as follows:—Multiply the length by half the breadth, or the breadth by half the length, and point off three figures as decimals; multiply the number thus obtained by '9, and the product will be the area within one-tenth of a bushel in every 50; a difference which is easily supplied by adding to the product '1, for every 50 bushels in the area. The content will be found by multiplying the area by the depth.

The areas of cisterns and other fixed utensils are entered in the Officer's book, so that it is only necessary to ascertain the depth of malt in the utensil at any particular time, and to multiply the area by such depth; the product will show the quantity of grain contained in the utensil.

- (4.) If a maltster's couch measure 178 inches long, 125 broad, and 50 deep, and it be filled with grain to the height of 32 inches, what is the area and content of the couch, and what is the quantity of grain in gross and net bushels?

$178 \times 125 \times .0004508 = 10.0303 \text{ area, and } 10.0303 \times 50 = 501.515 \text{ content};$
 Then, $10.0303 \text{ (area)} \times 32 = 320.9696 \text{ gross bushels.}$
 And $320.9696 \times .815 = 261.59 \text{ net bushels.}$

By the Sliding Rule.

178 on M D	125 on B	::	$\left\{ \begin{array}{l} 50 \\ 32 \end{array} \right\}$ on A	$\left\{ \begin{array}{l} 501.5 \\ 320.9 \end{array} \right\}$ on B.
Or, 125 on M D	50 on B	::	178 on A	501.5 on B.
And, 1 on A	.815 on B	::	320.9 on A	261.6 on B.

base according to the rules for the Mensuration of Superficies, and multiply such area by the perpendicular height ;

In finding the depth of the grain in a couch-frame (as in any other maltster's utensil), or on the floor, it is usual to take the number of dips in different parts of the grain in order to ascertain whether the surface be level, and if there be a slight variation in the depths, the different dips are added together, and divided by their number for a mean depth. The number taken is usually 10, and the mean is found by removing the decimal one place towards the left. Thus in the foregoing example, if there had been 10 dips of the grain (as in the margin), the mean depth would have been taken at 32, and the result would have been the same.

The net couch and cistern bushels are obtained by multiplying the gross bushels by .815, because 100 cistern or couch bushels are presumed to make 81.5 net bushels.

31.8
31.7
31.6
33.0
32.6
32.1
31.5
31.3
32.2
32.2

10)320.0

Mean 32

(5.) Required the content of a rectangular malt floor, 45 inches long, 20 broad, and 5 deep ?
 $45 \times 20 \times 5 \times .000451$ (p. 29) = 2.0295 bushels content.



By the Sliding Rule.

45 on M D : 5 on B :: 20 on A : 2.03 on B.

In practice, the contents of small floors may always be determined by the Sliding Rule ; but when the floor exceeds 200 bushels, the content cannot be ascertained so accurately by the Rule, because the tenths from 2 to 5, on the lines A and B, are only divided into two parts each, whilst those from 1 to 2 are divided into five parts each. *Floor charges*, whether large or small, should always be cast by the pen. See *Nisbet's Gauging*.

(6.) The length of a floor of malt is 329, the breadth 242, and the depth 5.6 inches ; required the content in gross and net bushels respectively ?

$329 \times 242 \times 5.6 \times .000451 = 201.08$ gross bushels.

Then, $201.08 \times .5 = 100.5$ net bushels.

By the Sliding Rule.

242 on M D : 5.6 on B :: 329 on A : 201 on B.

The net bushels in a floor are obtained by multiplying the gross bushels by .5, because 100 floor bushels are presumed to make 50 net bushels.

(7.) If the length of a floor be 485, breadth 224, depth 3.4, what is the content in gross and net bushels ?

166.5 gross, and 83.2 net. Ans.

A useful rule for casting floors mentally is the following :—Cut the two right-hand figures off the length and one off the breadth, or *vice versa*, and multiply for even thousands ; then to divide by 2218.192, first divide by 2, and for the second 2, subtract $\frac{1}{10}$ from the remainder, which gives the area nearly ; thus, if a floor be 400 inches long by 300 broad, and 4 deep, say, 4 (=400—the two last ciphers) $\times 30$ (=300—one cipher) = 120 $\div 2 = 60$. Then $60 - 6$ (= $\frac{1}{10}$ of 60) = 54 the area ; and 54×4 (depth) = 216 bushels content. If the units' and tens' places be not ciphers, take the nearest fraction which those numbers would make of 10 or 100 respectively, and add it to the multiplier, as in the following examples :—

(8.) L 316, B 219, D 4. Say $3\frac{1}{4}$ (for 316) $\times 21$ (=219—the units figure) = 68 $\div 2 = 34$. Then $34 - \frac{3}{4}$ (= $\frac{1}{10}$ of 34) = 31 (area), $\times 4$ (depth) = 124 bushels content.

the product will be the content in inches, which may be reduced into any other denomination by the proper divisor

	L	B	D		Area.	Content.
(9.)	31.8	$\times 2.16$	$\times 4$	$= 31 \times 2\frac{1}{2} = 69$, and $69 \div 2 = 34\frac{1}{2} = 31 \times 4 = 124$.		
(10.)	2.16	$\times 18.4$	$\times 2.5$	$= 18 \times 2\frac{1}{2} = 40$, and $40 \div 2 = 20 = 18 \times 2\frac{1}{2} = 45$.		
(11.)	4.48	$\times 32.2$	$\times 3$	$= 32 \times 4\frac{1}{2} = 144$, and $144 \div 2 = 72 = 65 \times 3 = 195$.		

If a malt floor be slanting at one end, by reason of the inclination of a wall or otherwise, and happen to slant at the other in the same proportion, it is still a rectangular prism, and its content is found as before.

SOAP FRAMES.

(12.) If a hard soap frame measure 45 inches long, 15 broad, and 12 deep, what is its area and content in pounds of common hot and cold hard soap respectively?

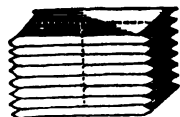
$45 \times 15 = 675 \div 28$ (or by 4 & 7) $= 24.107$ hot area.

And $675 \div 27.14$ (or $\times .0368$) $= 24.87$ cold area.

Then $24.107 \times 12 = 289.284$ hot content.

And $24.87 \times 12 = 298.44$ cold content.

The area in this and similar examples may be found by the use of factors, or in various other ways, as shown in p. 78. But the length and breadth of soap frames being fixed at 45 and 15, by act of parliament, the areas having been once calculated, are taken as constant, and entered in the officer's book accordingly; it is, therefore, only necessary to multiply such area by the depth found in the frame at any given time to find the solid content in pounds weight. The areas calculated upon the different kinds of soap as regulated by the Act are inserted in Table No. 30, in the Appendix.



By the Sliding Rule.

By the { 1 on A : { $\frac{24.107}{24.87}$ } on B :: 12 on A : { $\frac{289}{298}$ } on B

By a mean proportional { 15 on C : 15 on D :: 45 on C : 26 on D ; then
tional & gauge point { $\frac{5.29}{5.21}$ } on D : 12 on C :: 26 on D : { $\frac{289}{298}$ } on C
(see p. 65.)

By the line M D { $\frac{1188}{1225}$ } on M D : 45 on B :: 12 on A { $\frac{289}{298}$ } on B
(see p. 67.)

The exact mean proportional between the two dimensions is 25.98, but 26 is perhaps as near as it can be worked on the sliding rule. This mean, for the reason stated above, may be taken as *constant*, and will, therefore, not require a separate operation on the rule. The modified gauge points 1188 and 1225 are found by multiplying the constant gauge points 79.2 and 81.7 by 15, the breadth of the frame. (See p. 67.)

(13.) If a soap frame contain soap made from ordinary materials in a high pressure boiler, to the depth of 72 inches; what is the content when hot and cold respectively?

25.224 } (area, see Tab. No. 30) $\times 72$ { $= 1816.13$ lbs. high press. hot content.
 26.051 } { $= 1875.87$ lbs. do. cold content.

By the Sliding Rule.

1 on A : { $\frac{25.22}{26.05}$ } on B :: 72 on A { $\frac{1816}{1875}$ } on B

(14.) If there be in a soap frame 72 inches of soap, containing silicious or earthy matter, what is the content when cold and hot respectively?

28.078 } (area, see Tab. 30) $\times 72$ { $= 2021.61$ lbs. silicated hot.
 28.97 } { $= 2085.84$ lbs. do. cold.

By the Sliding Rule.

1 on A : { $\frac{28.08}{28.97}$ } on B :: 72 on A : { $\frac{2021}{2085}$ } on B.

or factor. Or, find the area of the base in gallons, bushels, &c., and multiply the same by the perpendicular height;

(15.) If a soapmaker has in one of his soap frames 66 inches of hard soap, of the specific gravity of 1.03; in another 80 inches, of the specific gravity of 1.02; in another 100 inches, of the specific gravity of 1.07; and in another 102 inches, of the specific gravity of 1.08. How many pounds must be charged in each case as hot or cold respectively?

1.03 and 1.02 being less than 1.05, the legal standard, the soap must in these cases be charged as common; and 1.07 and 1.08 being above such standard, the soap must be charged as silicated; then for the hot content say:

$$24 \cdot 107 \times \left\{ \begin{array}{l} 66 = 1591 \cdot 06 \\ 80 = 1928 \cdot 56 \end{array} \right\} \begin{array}{l} \text{common} \\ \text{soap} \end{array} \quad 28 \cdot 078 \times \left\{ \begin{array}{l} 100 = 2807 \cdot 8 \\ 102 = 2863 \cdot 95 \end{array} \right\} \text{silicated.}$$

And for the cold content say:

$$24 \cdot 87 \times \left\{ \begin{array}{l} 66 = 1641 \cdot 42 \\ 80 = 1989 \cdot 60 \end{array} \right\} \begin{array}{l} \text{common} \\ \text{soap} \end{array} \quad 28 \cdot 97 \times \left\{ \begin{array}{l} 100 = 2897 \cdot 00 \\ 102 = 2954 \cdot 94 \end{array} \right\} \text{silicated.}$$

RECTANGULAR DISTILLERY VESSELS.

(16.) What is the content in gallons of a rectangular vessel, the length of which is 45 inches, breadth 15 inches, and depth 10 inches?

$45 \times 15 \times .0036065 = 2.4344$ area, (p. 78). Then $2.4344 \times 10 = 24.344$ gals. content.

By the Sliding Rule.

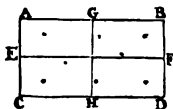
8 on M D : 45 on B :: 15 on A : 2.43 on B area. And $2.43 \times 10 = 24.3$ gals.

Or the operation may be performed on the line M D at once by obtaining a modified gauge point, p. 67; thus:—

120 (= 8 constant g. p. $\times 15$) on M D : 45 on B :: 10 on A : 24.3 on B.

If the vessel be large, as is usually the case with brewers' and distillers' backs, coolers, gulle-tuns, &c., it will be necessary to quarter the bottom and take the dimensions in different parts, in order to ascertain whether it be perfectly rectangular. This is done as follows:—With a dimension cane or tape, take the breadth of the end A C. Double the tape and extend it from A to E, at which place make a chalk mark, and you will have divided the end into two equal parts.

Find the middle of the end B D, and of the sides A B and C D, in the same manner. Measure E F and G H, which, if the vessel does not differ materially from a rectangle, may be taken for a mean length and breadth. If the vessel be large, each side should be divided the same as the bottom, and the divisions struck from top to bottom with a chalk line. The lengths and breadths may then be taken at the opposite intersections of the lines, and if there be not much bulging out or warping, the average of these dimensions may be taken for the mean length and breadth. To find the mean depth:—Lay a straight rod diametrically across the top of the vessel, and let fall a plumb line to different points as at the places marked in the diagram; and if these be nearly alike, divide the sum of the depths by their number for a mean depth. If there be liquor in the vessel, the dips may be taken in the different parts from the surface of the liquor, unless there be a constant dipping place, in which case one dip will be sufficient. A constant dipping place is fixed upon by trying in different parts of the vessel until a place is found which coincides exactly with the mean depth. The place should not be far from the side of the vessel, and when determined on, should be marked with white paint. If no convenient place can be found which coincides exactly with the mean depth, a note must be made of the tenths required to be added to or taken from the dips to bring them to the proper depth.



the product will be the content in the denomination in which the area was found. This rule is equally applicable to

To inch and tabulate a vessel of this description. As the area when once found is the same all the way up, it is only necessary to add one area for every additional inch when tabulating from the bottom for wet inches, or to subtract one area from the whole content for every inch when tabulating for dry inches. In tabulating for wet inches, we begin at the bottom; and for dry inches, at the top.

EXAMPLE OF A TRIANGULAR PRISM.

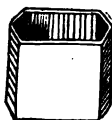
(17.) One side of the base of a triangular prism is 40; another, 38; and the other, 32; and the depth 50, required the content?

445 area, (p. 80) $\times 50 = 22250$ inches content.

EXAMPLE OF A HEXAGONAL PRISM.

(18.) One of the equal sides of a hexagonal prism is 72 inches, and its depth 32 inches, required its content in gallons?

13468.42 area (p. 83) $\times 32 \times .003606 = 1554.14$ gallons content.



EXAMPLES OF A CYLINDER.

(19.) Suppose a distillery store cask, in the form of a cylinder, be 42 inches in diameter, and 100 deep, what is its content in gallons?

$42^2 \times .00283257 = 4.9966$ area (p. 87). Then $4.9966 \times 100 = 499.66$ gals. content.

The base of a cylinder being a circle, the area in this and similar examples may be found either by divisors or factors, or the sliding rule, or the table of circular areas, as shown in p. 87; and, in any case, such area only requires to be multiplied by the depth, as above, to obtain the content. Or the content may be found, at one operation, by the following compendious formula.

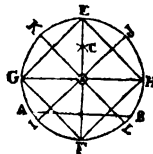


By the Sliding Rule.

18.79 (I M G Gauge Point) on D : 100 on C :: 42 on D : 499 on C.

If the vessel be large, as is the case with most distillery utensils, it will be necessary to quarter the bottom, and take the dimensions in different parts, to ascertain that it is exactly circular. This may be

done as follows:—With a chalk-line strike a line in any part of the bottom, as A B, and from centres, A, and B, describe arcs cutting each other in C; through the point C, and the middle of the line A B, erect the perpendicular E F, the middle of which, O, will be centre of the figure. From the point O, on each side of E F, draw a perpendicular O G, and O H, when the bottom will be quartered in the points E, H, F, G. Between these points strike the lines E H, H F, F G, and G E; and through the middle of these lines strike the lines I O J, and K O L, when the periphery will be divided into eight equal parts.—*Board Instructions for Gauging and Tabulating Distillery Utensils.*



A shorter mode of squaring the vessel, and one which for general purposes, will answer, is, to take a mean of two cross diameters, and multiply it by .707, the product is the length of the side of the inscribed square; and by applying this length to the bottom of the vessel, as at F G, G E, E H, H F, it will be divided into four equal parts, and from the angles, the cross diameters E F and G H may be drawn. The bottom of the vessel having thus been divided, diameters may be obtained in different parts; and, if necessary, a

Cylinders, and to elliptical and irregularly curved prisms as to rectangular prisms.

mean taken, as directed in the case of a rectangular vessel p. 103; and a mean depth and dipping-place may also be obtained in the manner there suggested.

The area of a cylinder being the same throughout, the quantity of liquor contained in it at any given time is easily ascertained by taking the depth, and multiplying the area by it; and to inch and tabulate a vessel of this description, it is only necessary to add one area for every inch when tabulating upwards, or subtract one area for every inch from the whole content when tabulating downwards.

If the sides of the vessel be not parallel for the whole of its depth, it is not a cylinder, and must be measured either as a frustum, prismoid, or distillery vat.—*Vide infra*.

(20.) Suppose the foregoing store cask to contain spirits 30 per cent. over proof to the depth of 84 inches; required its content in gallons at proof?

4.9966 (area as above) $\times 84 = 419.7144$. Then $419.7144 \times 130 \div 100$ (p. 44) = 545.628 gallons at proof.

By the Sliding Rule.

18.79 on D : 84 on C :: 42 on D : 419.7 on C.

Then (p. 59) 100 on A : 419.7 on B :: 130 on A : 545.6 on B.

(21.) Suppose the foregoing store cask to contain spirits at 30 per cent. under proof, to the depth of 60 inches; required its content in gallons at proof?

$4.9966 \times 60 \times 70 (= 100 - 30 \div 100) = 209.8572$ gallons at proof.

By the Sliding Rule.

18.79 on D : 60 on C :: 42 on D : 299.8 on C.

And 100 on A : 299.8 on B :: 70 on A : 209.8 on B.

(22.) Suppose the circumference of a store cask be 132 inches, and depth 100; what is its content?

$132^2 \times .000287 = 5.000688$ area, (p. 87). Then $5.000688 \times 100 = 500.0688$ gals. Ans.

By the Sliding Rule.

59 (Tab. 30) on D : 100 on C :: 132 on D : 500 on C, gals. Ans.

This gauge point, 59, being the square root of 3484.22 (p. 85), is very convenient in consequence of its being a whole number, and enables us to obtain a more correct result, when circumferences are taken, than by any other formula on the Sliding Rule. When circumferences are taken instead of diameters, an allowance must be made for the thickness of the vessel.

Another mode of finding the content is, to reduce the circumference to its equivalent diameter by the Table No. 34, and then to find the area from the Table of Circular Areas, No. 40.

(23.) Required the content of 4 different sections of the top of a still, representing cylinders whose dimensions are as follows: (1.) Circumference 37, Height 22. (2.) C 57 H 22. (3.) C 12.8 H 24. (4.) C 31.6 H 36!

By Table of Circumferences, No. 41.

(1.) $37 = .3929 \times 22 = 8.6438$ gals. (2.) $57 = .9324 \times 22 = 20.5128$ gals. (3.) $12.8 = .04706 \times 24 = 1.12944$ gals. (4.) $31.6 = .2851 \times 36 = 10.2636$. Ans.

By the Sliding Rule.

59 on D : $\begin{Bmatrix} 22 \\ 22 \\ 24 \\ 36 \end{Bmatrix}$ on C :: $\begin{Bmatrix} 37 \\ 57 \\ 12.8 \\ 31.6 \end{Bmatrix}$ on D : $\begin{Bmatrix} 8.6 \\ 20.5 \\ 1.12 \\ 10.26 \end{Bmatrix}$ on C gals. content.

See Stills, *infra*, where the contents in the above examples are found from the diameters.

II. PYRAMIDS.*

A *Pyramid* is a solid, standing on a base of any form, and terminated in a point at the vertex. Like the prism, it takes particular names from the figure of the base, as a *Square Pyramid*, a *Triangular Pyramid*, a *Pentagonal Pyramid*, &c.

EXAMPLE OF AN ELLIPTICAL PRISM.

(24.) What is the content in gallons of a distillery vessel, in the form of an elliptical prism, or cylindroid, the transverse diameter being 105·3, conjugate diameter 55·8, and depth 100 inches?



$16\cdot6434$ area (p. 90) $\times 100 = 1664\cdot34$ content in gallons.

The area may be found either by divisors, or factors, or by the Sliding Rule, or more readily by the table of circular areas, as shown in p. 91; and in any case only requires to be multiplied by the depth to get the content.

By the Sliding Rule.

105 on C : 105 on D :: 55·8 on C : 76·6 mean proportional on D. Then
18·79 on D : 100 on C :: 76·6 on D : 1664 on C.

Or 628 (mod. G. P. = $6\cdot28 \times 100$) on M D : 105·3 on C :: 55·8 on A : 1664 on B.

If the ellipsis be true for the whole length of the cask, the vessel is easily tabulated, but if the sides bulge out, it must be gauged and tabulated according to the instructions for Distillery Vats, *infra*.

The general method of finding the centre of an elliptical figure, in order to obtain the dimensions, is to let an assistant hold one end of a tape, and by repeated trials to find the largest diameter, which is then struck with a chalk line. By the same method the conjugate diameter is determined, being always the largest that can be found within the figure perpendicular to the transverse.—*Nisbet's Gauging*. When the bottom of the vessel is nearly circular, it may be quartered as a cylinder, p. 104. When it is more irregular in its curve, it must be divided, according to the directions for Distillery Vats, *infra*.

EXAMPLE OF AN IRREGULAR PRISM.

(25.) Let the base of a spirit-receiver be represented by the fig. in p. 94, whose transverse diameter is 112 inches, and five perpendicular ordinates 70, 79, 80, 78·6, 69; common distance 24; the height of the segments at the ends each 8, and depth 50; what is its content in gallons?

$29\cdot48$ area (p. 94.) $\times 50 = 1474$ gallons, content.

If there be any deviation from the perpendicular in any part of the sides of the vessel, which can only be ascertained by a sufficient number of measurements, the use of the plumb line, &c., a different mode of calculation must be adopted. See Distillery Vats, *infra*.



* A *Pyramid* is usually defined as an angular solid, which has a polygon for its base, and triangles for its sides or faces, the sides all meeting in one point, and forming a solid angle, which is called the vertex of the pyramid. A *Cone*, like a cylinder, has a circular base, but it terminates in a point like other pyramids. It may be conceived to be described by the revolution of a right-angled triangle about one of its legs, which remains fixed. Sections made by cutting a cone in different ways, and describing various superficial figures,

A *Cone* may also be considered as a pyramid, having for its base a regular polygon of an infinite number of sides. If the perpendicular from the vertex falls on the centre of the base, the solid is called a *right* pyramid; but if not, it is *oblique*.

*To find the content.**—Multiply the area of the base by one third of the perpendicular height; the product is the content.

are called *Conic Sections*. The altitude of a pyramid or cone is its perpendicular height; and the *slant height* is a straight line drawn from the vertex to the outer edge of the base. A *Segment* is a part cut off from the top by a plane parallel to the base; and a *Frustum* is the part remaining after the segment or top is removed. A pyramid, a triangular prism, and a parallelopipedon, standing upon the same base, and having the same altitude, are to one another as 1, $1\frac{1}{2}$, and 3. Hence, also, a cone is equal to the third part of a cylinder of equal base and altitude. The surface of a pyramid is equal to the areas of the triangles which constitute its sides; and the surface of a cone is equal to the product of half the circumference of the base by the sum of the slant side and the radius of the base.

A pyramid being one-third of a prism of equal base, the divisors for finding the content will be three times those used for prisms, namely, for inches, 3; for gallons, 831·822 ($=277\cdot274 \times 3$); and for bushels, 6654·57 ($=2218\cdot192 \times 3$). The factors will be one-third of those used for prisms, namely, for inches, ·333 ($=1 \div 3$); for gallons, ·001202 ($=0\cdot03606 \div 3$); and for bushels, ·00015 ($=0\cdot00451 \div 3$). For the same reason the conical divisors will be three times the circular divisors, namely, for inches, 3·8197 ($=1\cdot2732 \times 3$); for gallons, 1059·108 ($=353\cdot036 \times 3$); and for bushels, 8472·87 ($=2824\cdot29 \times 3$). The factors will be one-third of the circular factors, namely, for inches, ·2618 ($=7854 \div 3$); for gallons, ·000944 ($=0\cdot02832 \div 3$); and for bushels, ·000118 ($=0\cdot00354 \div 3$). The gauge points are in every case the square roots of their corresponding divisors. See Table No. 30.

*** EXAMPLE OF A TRIANGULAR PYRAMID.**

(1.) Required, the content of a triangular pyramid, the perpendicular height being 50 inches, and the sides of the base 40, 28, and 32?

445 area, (p. 80) $\times 50 \div 3 = 7416\cdot66$ inches, content.

An equilateral triangular pyramid is a *tetrahedron*, one of the five regular bodies; and its content may be found by multiplying the cube of one of its sides by 0·11785.



EXAMPLE OF A SQUARE PYRAMID.

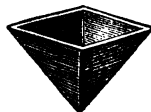
(2.) Required, the content, in gallons and bushels, of a square pyramid, the side of the square being 22 inches, and the height 30 inches?

484 area, (p. 77) $\times 30 \div 831\cdot822 (=277\cdot274 \times 3) = 17\cdot45$ gallons.

And $17\cdot45 \div 8 = 2\cdot18$ bushels. Ans.

By the Sliding Rule.

$28\cdot84 (= \sqrt{831\cdot82} \text{ pyr. div. } supra) \left. \vphantom{28\cdot84} \right\} \text{ on : } 30 \text{ on C : } 22 \text{ on D } \left\{ \begin{array}{l} 17\cdot45 \\ 2\cdot18 \end{array} \right\} \text{ on C.}$
 $81\cdot57 (= \sqrt{6654\cdot57}) \left. \vphantom{81\cdot57} \right\}$



III. PYRAMIDICAL FRUSTUMS, PRISMOIDS, AND WEDGES.*

A frustum of a pyramid or cone is the part remaining after a segment has been cut off from the top by a plane

EXAMPLE OF A HEXAGONAL PYRAMID.

(3.) One of the equal sides of a hexagonal pyramid is 72 inches, and depth 32 inches, required its content in gallons?

13468·42 area of base (p. 83) $\times 32 \times \cdot 001202$ ($= \cdot 003606 \div 3$) $= 518 \cdot 04$ galls. content.

EXAMPLE OF A CONE.

(4.) Let the diameter of a conical vessel be 42 inches, and the depth 100, required its content in gallons?

4·9966 area (pp. 86, 104) $\times 100 \div 3 = 166 \cdot 55$ gallons content.



By the Sliding Rule.

32·54 ($= \sqrt{1059 \cdot 108}$ con. div.) on D : 100 on C
C :: 42 on D : 166 on C.

(5.) What is the content of a heap of malt in the form of a cone, the diameter of the base being 260, and the depth or perpendicular height 120?

Ans. 957·4 bushels.

* FRUSTUMS, &c.

As these solids, although differing materially in form, may all be measured according to the same general principles, it has been found convenient to include them under one general heading. The first Rule in the text is of great value and extensive application. As applied to square solids (and by the use of proper divisors all bodies not already square may be reduced to that form), it may be expressed thus:—Add together the square of the top, the square of the bottom, and four times the square of the middle, and multiply the sum by one-sixth of the depth. But four times the square of a number is equal to the square of twice that number, therefore the rule becomes still easier. Add together the square of the *top*, the square of the *bottom*, and the square of *twice the middle*, and multiply by one-sixth of the depth. Moreover, when solids do not bulge in the middle, like globes and spindles, but taper regularly like cones and pyramids, then the sum of the top and bottom *will be* twice the middle diameter. Therefore, for all regularly tapering frustums, the above rule becomes still more concise, and assumes the expression of the 2nd rule in the text. The two rules are thus in reality the same; they both require us to add together the areas of the two ends, and the area of a figure equal in dimensions to the sum of the dimensions of both ends, and multiply by one-sixth of the height for the contents. Instead of multiplying by one-sixth of the height, however, we may take the *whole* of the height, and divide by six times the square or circular divisor for gallons, bushels, &c. Hence, six times the square divisors are called divisors for square frustums, viz. 1663·644 ($= 277 \cdot 274 \times 6$) for gallons, and 13309·15 ($= 2218 \cdot 192 \times 6$) for bushels; and six times the circular divisors are divisors for round frustums, viz. 2118·216 ($= 353 \cdot 036 \times 6$) for gallons, and 76945·74 ($= 12824 \cdot 29 \times 6$) for bushels. The factors are the reciprocals, and the gauge points the square roots of these divisors respectively. (See Table 30, in the Appendix.) See also *Kentish's Treatise*.

parallel to the base. If the lower frustum of two unequal cones are joined together at the greater end, they assume

The general rule adopted in *Gutteredge's Gauger*, "as sufficient to find the content of any vessel, either of four sides or curved, the sides whereof are straight from top to bottom, whether the bases are equal or unequal, alike or unlike, proportional or disproportional, alike situated or inverted, the one base a square, the opposite a parallelogram, or the one an ellipsis, and the other one a circle," is as follows:—To the length or transverse diameter of the greater base, add half the length, or half the transverse diameter of the less base, and multiply this sum by the breadth of the greater base. To the length or transverse diameter of the less, add half the length, or half the transverse diameter of the greater base, and multiply the sum by the breadth of the less base. Add the two sums found as above, and multiply the total by one-third of the depth: the product is the content.

EXAMPLES OF A FRUSTUM OF A SQUARE PYRAMID.

(1.) Required the content of the frustum of a square pyramid, the side of a square of the base being 22 inches, and of the top 16, and the depth of the frustum 20!

$$\begin{array}{rcl} \text{Top} & . & 16^2 = 256 \\ \text{Bottom} & . & 22^2 = 484 \\ \text{Sum} & . & 38^2 = 1444 \end{array}$$

$$2184 \times 20 \div 6 = 7280 \text{ inches content.}$$

(2.) Required the content in gallons of a square pyramidal guile-tun, the side of the larger end being 42·5, and of the smaller 30, and the depth 36!

$$\begin{array}{rcl} \text{Larger end} & 42\cdot5^2 & = 1806\cdot25 \\ \text{Smaller end} & 30^2 & = 900 \\ \text{Sum} & . & . & 72\cdot5^2 = 5256\cdot25 \end{array}$$

$$7962\cdot5$$

$$\text{Then } 7962\cdot5 \times 36 \div 1663\cdot644 = 172\cdot302 \text{ gals. content.}$$

By the *Sliding Rule*.

$$40\cdot79 \text{ on D : } 36 \text{ on C :: } \left\{ \begin{array}{l} 42\cdot5 \\ 30 \\ 72\cdot5 \end{array} \right\} \text{ on D : } \left\{ \begin{array}{l} 39 \\ 19 \\ 114 \end{array} \right\} \text{ on C. } 172 \text{ gals.}$$

This is a very useful formula, as the slider remains fixed throughout the three calculations when once properly set. The gauge point is the square root of 1663·644. (See p. 108.)

By *Table of Semisquares*.

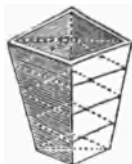
Tab. number (Tab. 38)	42·5	= 3·2572
Ditto ditto	30	= 1·6229
Ditto (for sum)	72·5	= 9·4784

$$14\cdot3585 \times 12 (=36 \div 3) = 172\cdot302 \text{ Ans.}$$

Here, in place of multiplying by one-sixth of the height, we multiply by one-third of it, the tables being only half the areas of the squares of their respective numbers.

For finding the content of a pyramidal frustum, the rule is sometimes expressed as follows:—To the rectangle of the sides of the two ends add the sum of their squares; that sum being multiplied into one-third of the height, will give the solidity. Thus, in the foregoing example:—

$$\begin{array}{l} 1806\cdot25 (=42\cdot5^2) + 900 (=30^2) = 2706\cdot25, \\ \text{Then, } 1275 (=42\cdot5 \times 30) + 2706\cdot25 \times 12 (=36 \div 3) = 47775 \text{ inches,} \\ \text{And, } 47775 \text{ inches} \times \cdot003806 = 172\cdot302 \text{ gals. content.} \end{array}$$



the form of a *Cask* of what is called the *fourth variety*. A *Prismoid* is usually defined to be a solid of any kind, (not

Another rule is as follows :—Find the whole length of the pyramid thus ; as the difference of the breadth of the two ends, is to the length between them, so is the breadth of the less end to the length of the part cut off ; then find the content of the whole pyramid and the content of the top part, and subtract the top from the whole ; the remainder will be the content of the frustum. Thus, in the foregoing example :— $12.5 : 36 :: 30 : 86.4$.
 $42.5^3 = 1806.25 \times 122.4 (=86.4 + 36) \div 3 = 73,695$, content of whole pyramid.
 $30^3 = 900 \times 86.4 \div 3 = 25,920$, content of part cut off.

Content of the frustum . . . $47,775 \times .003606 = 172.3$ gals.

To take the dimensions of a vessel of this description, the length and breadth of the bottom and top may be measured in the usual way. And to find the depth, lay a rod across the mouth and let fall a plummet to the bottom, and measure the length of the plumb line. This is all that is necessary, if the ends are even and the sides slant regularly. If it be required to inch and tabulate the vessel, it may be done by means of intermediate measurements, say at every six inches of its depth, as follows :—First find the differential factor, by subtracting the less diameter from the greater, and dividing the remainder by the depth of the vessel. Then multiply any proposed depth by the differential factor so found, add the product to the less side, if the proposed depth is reckoned from the smaller end, or subtract it from the greater side, if it be reckoned from the larger end ; the sum or difference will be the side at the depth proposed. Here the depth is reckoned from the larger end : therefore,

$42.5 - 30 = 12.5 \div 36 = .347$, differential factor.											
$6 \times .347 = 2.082$	} decrease of diameter at										
$12 \times .347 = 4.164$											
$18 \times .347 = 6.246$											
$24 \times .347 = 8.328$											
$30 \times .347 = 10.410$											
	<table> <tr> <td>6 in.</td><td>And $42.5 - 2.082 = 40.418$ dia. at 6 in. deep.</td></tr> <tr> <td>12 "</td><td>$42.5 - 4.164 = 38.336$ " 12 "</td></tr> <tr> <td>18 "</td><td>$42.5 - 6.246 = 36.254$ " 18 "</td></tr> <tr> <td>24 "</td><td>$42.5 - 8.328 = 34.172$ " 24 "</td></tr> <tr> <td>30 "</td><td>$42.5 - 10.410 = 32.090$ " 30 "</td></tr> </table>	6 in.	And $42.5 - 2.082 = 40.418$ dia. at 6 in. deep.	12 "	$42.5 - 4.164 = 38.336$ " 12 "	18 "	$42.5 - 6.246 = 36.254$ " 18 "	24 "	$42.5 - 8.328 = 34.172$ " 24 "	30 "	$42.5 - 10.410 = 32.090$ " 30 "
6 in.	And $42.5 - 2.082 = 40.418$ dia. at 6 in. deep.										
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24 "	$42.5 - 8.328 = 34.172$ " 24 "										
30 "	$42.5 - 10.410 = 32.090$ " 30 "										

Then, by Table of Semi-squares.

1st. Frustum	Top . 42.5 = 3.2572		
	Bottom 40.4 = 2.9432		
	Sum . 82.9 = 12.3928	18.5932 $\times 2$ ($= 6 \div 3$) = 37.1864	gals. content.
2nd. Frustum	Top . 40.4 = 2.9432		
	Bottom 38.3 = 2.6452		
	Sum . 78.7 = 11.1689	16.7573 $\times 2$ " "	33.5146
3rd. Frustum	Top . 38.3 = 2.6452		
	Bottom 36.2 = 2.3631		
	Sum . 74.5 = 10.0086	15.0169 $\times 2$ " "	30.0338
4th. Frustum	Top . 36.2 = 2.3631		
	Bottom 34.2 = 2.1092		
	Sum . 70.4 = 8.9373	13.4096 $\times 2$ " "	26.8192
5th. Frustum	Top . 34.2 = 2.1092		
	Bottom 32.1 = 1.8581		
	Sum . 66.3 = 7.9266	11.8939 $\times 2$ " "	23.7878
6th. Frustum	Top . 32.1 = 1.8581		
	Bottom 30.0 = 1.6229		
	Sum . 62.1 = 6.9542	10.4352 $\times 2$ " "	20.8704

Total content of vessel, 172.3122

included in the foregoing definitions), of which the bases are parallel, and the greatest and least thickness are its

If the less end of the vessel had been uppermost, the numbers found by the differential factor would have been *excess* of diameter instead of *deficiency*, and must have been severally added to 30, the less diameter.

By this mode it is evident that the content of every inch or tenth of an inch may be found, if required. But if the slanting of the vessel be inconsiderable, the content of each frustum may be divided into equal parts by the number of inches in its depth; and the quotient taken as a common area for that section; then to tabulate the vessel for every dry inch at every inch of its perpendicular depth, subtract the area of the first section from the whole content, and the remainder will be the content at one inch of its depth; from this subtract the same area, and the remainder will be the content at two inches; and thus continue subtracting the area of the first section till you come to the sixth inch in this example, and you will have the content of the vessel at every inch of the first six inches of its perpendicular depth, from the top. From this content take the area of the second section, found in the same way as the first, and you will obtain the content at seven inches; and thus proceed till you come to the bottom of the vessel, always changing the area at every six inches, and the vessel will thus be inched and tabulated. For the mode of tabulating for wet inches, see Distillery Vats, *infra*.

If the slant in the sides of the vessel be only small, it might be sufficient to take four or five diameters only as marked in the diagram. If the deviation from a pyramidal form be considerable, the vessel should be gauged by ordinates (see p. 92.)

EXAMPLE OF THE PRUSTUM OF A TRIANGULAR PYRAMID.

(3.) Required the content of the frustum of a triangular pyramid, the height of the frustum being 14 inches; the sides of the greater base 21, 15, and 12; and those of the less base 14, 10, and 8 inches?

Area of top (p. 80) . . . 39.19
Area of bottom . . . 88.18
Area of sum of sides . . 244.95



$$372.32 \times 14 \div 6 = 868.74 \text{ in. Ans.}$$

The same result would be obtained by adding to the areas of the top and bottom a mean proportional between them, and multiplying the sum by one-third of the height, thus: $88.18 \times 39.19 = 3455.7742$ $\sqrt{3455.7742} = 58.78$. And $88.18 + 39.19 + 58.78 = 186.15 \times 14 \div 3 = 868.7$ inches.

EXAMPLE OF THE PRUSTUM OF A HEXAGONAL PYRAMID.

(4.) What is the content of the frustum of a hexagonal pyramid, one side of the larger base being 20 inches, and of the smaller 15, and the depth 36?

$$20^2 = 400$$

$$15^2 = 225$$

$$35^2 = 1225 \quad 1850 \times 2.5980762 \text{ (tab. No. for hex.)} \times 6$$

$$= 36 \div 6 = 28838.64582 \text{ in. Ans.}$$



For galleons, the usual divisors or factors may be used, or the areas may be found in the table of semi-squares. The content of the frustums of all other regular polygons may be obtained in the same manner as the above by using the proper tabular number. Or, by the following rule:—Add a side of the greater base to one of the less, and from the square of the

ends. When its sides are any dissimilar curves, it is sometimes called a *Cylindroid*. A *Wedge* is a solid of a

sum, subtract the product of those sides; the remainder, multiplied by the proper tabular number and by one third of the height, will give the content.

EXAMPLES OF A CONICAL FRUSTUM.

(5.) Required the content of the frustum of a cone, the diameter of the base being 20 inches, the diameter at the top 12, and the depth 36?

$$20^2 = 400$$

$$12^2 = 144$$

$$32^2 = 10241 \quad 568 \times 6 (= 36 \div 6) \times .7854 = 7389.0432 \text{ in. Ans.}$$



(6.) Suppose the top diameter of a store cask in the form of a conical frustum be 60.2 inches, bottom diameter 98.5, and depth 82.8, required the content?

$$60.2^2 = 3624.04$$

$$98.5^2 = 9702.25$$

$$158.7^2 = 25185.69 \quad 38511.98 \times 82.8 \div 2118.216 (\text{cir. frus. div. tab. 30}) = 1505.41 \text{ gals.}$$

By the Sliding Rule.

$$46 \text{ on D : } 82.8 \text{ on C :: } \left\{ \begin{array}{l} 60.2 \\ 98.5 \\ 158.7 \end{array} \right\} \text{ on D : } \left\{ \begin{array}{l} 142 \\ 379 \\ 984 \end{array} \right\} \text{ on C} \quad \left. \begin{array}{l} \\ \\ \end{array} \right\} 1505 \text{ gals.}$$

This gauge point, being the square root of 2118.216 (see p. 108), is very convenient in consequence of its being a whole number.

By the Table of Circular Areas.

$$60.2 = 10.2653$$

$$98.5 = 27.4823$$

$$158.7 = 71.3402 \quad 109.0878 \times 13.8 (= 82.8 \div 6) = 1505.41 \text{ gals. content.}$$

The content of a conical frustum may also be obtained by either of the following rules:—I. Add the diameter of the greater base to that of the less, and from the square of the sum subtract the product of those diameters; the remainder multiplied by .7854, or the proper circular factor, and the product by one third of the depth, will give the content. II. To one fourth of the area of a circle whose diameter is equal to the sum of the top and bottom diameters of the frustum, add $\frac{1}{4}$ of the area of a circle whose diameter is the difference of the aforesaid diameters; multiply the sum by the height or depth, and the product will be the content.

If it be necessary to inch and tabulate a vessel of this description, the bottom may be quartered or subdivided, as directed in p. 104. And by means of a plumb-line the corresponding points may be set out at the top of the vessel. Perpendiculars may then be struck with a chalk-line from the bottom to the mouth of the vessel, by means of which cross diameters may be taken at any required depth.

If it be required to inch and tabulate the vessel by means of intermediate diameters at every 10 inches of its depth; find the differential factor as above directed for square frustums. In this case it will be $98.5 - 60.2 = 38.3 \div 82.8 = .46256$, which being multiplied by the intermediate depth, and the product (here 4.6) added to the less diameter (being in this case reckoned from the smaller end at the top), gives the diameters of the different frustums, as shown in the following scheme, the areas being taken from the Table of Circular Areas, No. 40,

rectangular base, having two of its opposite sides terminating in an edge.

No.	Inches from Top.	Diameters.	Tabular Area.	Total.	Gals. Content.
1	10	Top . . 60.2	10.2858	$66.4182 \times 10 \div 6 = 110.697$	
		Bottom. 64.8	11.8940		
		Sum . . 125.0	44.2589		
2	20	Top . . 64.8	11.8940	76.5501	127.583
		Bottom. 69.4	13.6426		
		Sum . . 134.2	51.0135		
3	30	Top . . 69.4	13.6426	87.5247	145.874
		Bottom. 74.1	15.5531		
		Sum . . 143.5	58.3290		
4	40	Top . . 74.1	15.5531	99.2315	165.386
		Bottom. 78.7	17.5440		
		Sum . . 152.8	66.1344		
5	50	Top . . 78.7	17.5440	111.5367	185.994
		Bottom. 83.3	19.6548		
		Sum . . 162.0	74.3379		
6	60	Top . . 83.3	19.6548	124.7082	207.847
		Bottom. 88.0	21.9354		
		Sum . . 171.3	83.1180		
7	70	Top . . 88.0	21.9354	138.6121	231.020
		Bottom. 92.6	24.2886		
		Sum . . 180.6	92.3881		
8	80	Top . . 92.6	24.2886	153.0902	255.150
		Bottom. 97.2	26.7616		
		Sum . . 189.8	102.0400		
9	82.8	Top . . 97.2	26.7616	$162.7269 \times 2.8 \div 6$	75.939
		Bottom. 98.5	27.4828		
		Sum . . 195.7	108.4830		

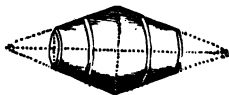
Total content of vessel . . . 1505.390

The tabulation being in this case from the top, the last or bottom frustum was only 2.8 inches in depth. Had the greater end of the vessel been uppermost, the numbers found by the differential factor would have been *deficiency* of diameter instead of *excess*, and subtracted instead of added. (See Square Frustums, *supra*.)

(7.) If a section of a still, in the form of a frustum of a cone, measure as follows: top diameter, 13.7; bottom, 30.7; altitude, 39; what is the content? Ans., 57.1038 gals.

EXAMPLE OF THE DOUBLE FRUSTUM OF A CONE.

(8.) If a solid, in the form of two equal conical frustums, joined together at the greater base, usually called a cask of the fourth variety, be 40 inches long, 32 middle or bung diameter, and $\frac{3}{4}$ the end or head diameter, what is the content?



$$32^2 = 1024$$

$$24^2 = 576$$

$$56^2 = 3136 \quad 4786 \times 40 \div 6 \times .002832 = 89.4 \text{ gals. content.}$$

To find the content. I.—Find the area of the top, the area of the bottom, and four times the middle area, and

By the Sliding Rule.

$$46 \text{ (cir. frus. G P, as above) on D : 40 on C :: } \begin{Bmatrix} 32 \\ 24 \\ 56 \end{Bmatrix} \text{ on D : } \begin{Bmatrix} 19.3 \\ 10.9 \\ 59.2 \end{Bmatrix} \text{ on C}$$

By the Table of Circular Areas.

$$32 = 2.9005$$

$$24 = 1.8315$$

$$56 = 8.8829 \quad 13.4149 \times 40 - 6 = 89.432 \text{ gals. content.}$$

It will be observed that the operation is exactly the same as for a single frustum, showing that the comprehensive rule in the text is equally applicable to two frustums as to one, when the ends are equal, and the sides slant regularly from one base to another. It evidently makes no difference, whether the larger base be in the middle, or at one end. If the ends are not equal, it will be necessary to divide the frustum into two parts; but even in that case the content may be found by Rule I. In all cases where the middle areas can be found, this is the most correct way of measuring vessels of this description. Even if the sides bulge out irregularly, this rule may be usefully applied, provided middle diameters can be obtained between the largest base and each of the smaller ones. (See the Examples, *infra*.)

Although the double frustum of a cone is usually reckoned as a cask of the fourth variety, such a figure is rarely met with in practice, the usual shapes of casks and tubs being more spheroidal; that is, they have an arched or swelling course from the middle or bung to the chine or end. The old method of finding the content of a cask of the fourth variety was, to multiply the difference between the head and bung diameters, when it was 6 inches or less, by .5; and, when it exceeded 6 inches, by .52, and to add the product to the head diameter, the sum being taken as a mean diameter between those of the head and bung, and used as the diameter of a cylinder, and the content found accordingly. Thus in the foregoing example: $32 - 24 = 8 \times .52 = 4.16 + 24 = 28.16^2 \times 40 \div 353.036 = 89.84$ gallons, being nearly half a gallon more than by the Rule in the text. To find the content upon the Sliding Rule upon the same principle a line was formerly marked, called *fourth variety*, which showed the difference to be added to the head diameter; but this line is disused in practice, casks being now all measured as spheroidal, and allowances made in the length when they vary from that figure.

EXAMPLES OF RECTANGULAR PRISMOIDS.

(9.) What is the content in gallons of a distiller's utensil in the form of a prismoid, of which the height is 264 inches, the upper base being a rectangle, of which the sides are 43 and 23; and the under base a square, of which the side is 37 inches?

$$43 \times 23 = 989$$

$$37 \times 37 = 1369$$

$$80 \times 60 = 4800 \quad 7158 \times 44 (= 264 \div 6) \times .003606 = 1135.7169$$

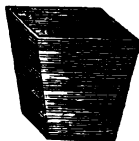
gals. Ans.

(10.) Required the content in gallons of a four-sided figure, whose opposite sides are equal and parallel at each base; the sides of the upper base being 30 and 20 inches, and of the lower 30 and 10, and the depth 30 inches?

$$30 \times 20 = 600$$

$$20 \times 10 = 200$$

$$50 \times 30 = 1500 \quad 2300 \times 30 \times .006601 (= .003606 \div 6) = 41.47 \text{ gals. Ans.}$$



multiply the sum by one sixth of the length ; or, multiply by the whole length, and divide by six times the square

By the Sliding Rule.

$$\text{By mean Proportionals } \left\{ \begin{array}{l} 30 \\ 20 \\ 50 \end{array} \right\} \text{ on C : } \left\{ \begin{array}{l} 30 \\ 20 \\ 50 \end{array} \right\} \text{ on D :: } \left\{ \begin{array}{l} 20 \\ 10 \\ 30 \end{array} \right\} \text{ on C : } \left\{ \begin{array}{l} 24.5 \\ 14.1 \\ 38.7 \end{array} \right\} \text{ on D}$$

$$\text{Then } 40.79 \text{ on D : } 30 \text{ on C :: } \left\{ \begin{array}{l} 24.5 \\ 14.1 \\ 38.7 \end{array} \right\} \text{ on D : } \left\{ \begin{array}{l} 10.8 \\ 3.6 \\ 27.1 \end{array} \right\} \text{ on C}$$

$$\text{By the line } \left\{ \begin{array}{l} 8 \text{ (G P for gals.)} \\ 240 \text{ on M D : } \left\{ \begin{array}{l} 30 \\ 20 \\ 50 \end{array} \right\} \text{ on B :: } \left\{ \begin{array}{l} 20 \\ 10 \\ 30 \end{array} \right\} \text{ on A : } \left\{ \begin{array}{l} 65 \\ 21.5 \\ 162.6 \end{array} \right\} \text{ on B} \end{array} \right\} \times 30 \text{ (depth of vessel) = 240 modified G P}$$

MD $249.1 \div 6 = 41.5$. Ans.
By dividing the modified G P (240) by 6, we obviate the necessity of dividing the sum of the contents by it, thus: $240 \div 6 = 40$.

$$40 \text{ on M D : } \left\{ \begin{array}{l} 30 \\ 20 \\ 50 \end{array} \right\} \text{ on B :: } \left\{ \begin{array}{l} 20 \\ 10 \\ 30 \end{array} \right\} \text{ on A : } \left\{ \begin{array}{l} 10.8 \\ 3.6 \\ 27.1 \end{array} \right\} \text{ on C}$$

In calculating the contents of prismoids, attention must be paid to the position of the sides ; for the top and bottom areas of two prismoids may be the same, and yet their middle area, and consequently their content, different. For suppose a prismoid to be 12 inches by 10 at the top, and 9 by 6 at the bottom, the 12 falling over the 9, and the 10 over the 6 ; if now we shift the position of the top parallelogram, so as to bring the short side over the long one of the bottom, then the figure becomes distorted, and the content altogether altered. In the first case the areas will be 510, and in the second 516, inches. (See *Kentish's Treatise*.)

(11.) If a heap of malt, in the form of a prismoid, measure at the lower base 100 inches by 80, and at the top 70 by 60, and depth 8, what is its content in bushels ?

$$100 \times 80 = 8000$$

$$70 \times 60 = 4200$$

$$170 \times 140 = 23800 \quad 36000 \times 8 \times .00007513 \text{ (Tab. 30)} = 21.64 \text{ bushels.}$$

By the Sliding Rule.

$$8 \text{ on M D : } \left\{ \begin{array}{l} 100 \\ 70 \\ 170 \end{array} \right\} \text{ on B :: } \left\{ \begin{array}{l} 80 \\ 60 \\ 140 \end{array} \right\} \text{ on A : } \left\{ \begin{array}{l} 28.8 \\ 15.1 \\ 86. \end{array} \right\} \text{ on B}$$

The above is the correct way of gauging a floor of malt in the form of a rectangular frustum or prismoid ; but in practice the operation is performed by a mean length and breadth. (See *MALT FLOORS, infra*.)

EXAMPLES OF THE FRUSTUM OF A CURVED PRISMOID.

(12.) Required the content of an elliptical cistern or cylindroid, the diameters of the larger base being 18 and 20, and of the lesser 12 and 14, and the depth 42 inches ?

$$20 \times 18 = 360$$

$$14 \times 12 = 168$$

$$34 \times 30 = 1020 \quad 1548 \times 7 (=42 \div 6) \times .002832 = 30.69$$

[gals. content.]

The areas may be obtained by the Sliding Rule, or more readily by the Table of Circular Areas (No. 40). The method of tabulation also would be the same as in p. 113, unless the vessel bulged out at the sides, in which case it must be measured by equidistant ordinates (p. 92.)



or circular divisor; the product or quotient, as the case may be, is the content.

(13.) What is the content in gallons of a distiller's vessel in the shape of a cylindroid, or solid, bounded at one end by a circle 6 inches in diameter, and at the other end by an ellipse whose axes are 12 and 10, and 24 inches deep?

$$\begin{array}{rcl} \text{Top} & . & 6 \times 6 = 36 \\ \text{Bottom} & 12 \times 10 = & 120 \\ \text{Sum} & . & 18 \times 16 = 288 \end{array}$$

$$444 \times 4 (24 \div 6) \div 353.036 = 5.03 \text{ gallons. Ans.}$$

(14.) Required the area of a vessel whose sides are straight, and of the depth of 60 inches; and the dimensions of whose bases, taken according to the directions of nine equidistant perpendicular ordinates, are as follow:—

Top.—Transverse 134; 1st perpendicular 40.8, 2nd 62.7, 3rd 76.3, 4th 82.9, 5th (conjugate) 85.2, 6th 83, 7th 76.1, 8th 62.8, 9th 41; sum of segments 14.

Bottom.—Transverse 124; 1st perpendicular 19.4, 2nd 54.0, 3rd 69.0, 4th 76.4, 5th (conjugate) 78.0, 6th 76.3, 7th 68.8, 8th 53.7, 9th 19.6; sum of segments 4.

Here the area of the top base, calculated according to the rules and examples in p. 94, &c., is 32.4398 gallons; the area of the bottom base, calculated according to the same rules and examples, is 27.4565, and the area of a figure, equal in dimensions to the dimensions of the top and bottom, is 119.2784; Then,

$$\begin{array}{rcl} \text{Upper base} & . & . & . & 32.4398 \\ \text{Lower base} & . & . & . & 27.4565 \\ \text{Sum of dimensions} & & & & 119.2784 \end{array}$$

$$179.1747 \times 10 (= 60 \div 6) = 1791.747 \text{ gallons.}$$

If a vessel bulges in the middle it is necessary to have a middle diameter, and to operate by the 1st rule in the text; and, in all cases where the curve is doubtful, such middle diameter should be obtained as in the following example:—

Suppose the middle dimensions of the above-mentioned vessel were taken as follows:—Transverse, 129; ordinates, 1st 30.1; 2nd 58.3; 3rd 72.7; 4th 79.6; 5th 81.6; 6th 79.7; 7th 72.4; 8th 58.3; 9th 30.3; sum of segments 9; the top and bottom bases and depth remaining as before, what is the content?

Here the middle area, found by rule in p. 95, is 29.8196 gallons.

$$\begin{array}{rcl} \text{Then, area of top} & . & . & . & 32.4398 \\ \text{" bottom} & . & . & . & 27.4565 \\ \text{" middle } 29.8196 \times 4 & & & & 119.2784 \end{array}$$

$$\begin{array}{rcl} & & 179.1747 \\ \text{Multiplied by } 60 \div 6 & . & . & . & 10 \end{array}$$

$$1791.747 \text{ gallons.}$$

In this example the ordinates of the middle diameter are taken pretty nearly as a mean between the ordinates of the top and bottom, and produce a result almost the same as by the former process. Had the ordinates of the middle section been greater than the mean, it is obvious that the content of the vessel would be proportionally greater.

II.—For a regularly tapering body, add together the square of the top, the square of the bottom, and the square of their

EXAMPLE OF A DOUBLE PRISMOID.

(15.) What is the content of a vessel in the form of a double prismoid, of which the whole length is 370 inches, the length from A to o, 160; the greatest girt, CD, 77; the greater end, EF, 54; the middle girt, GH, 67; girt of the less end, IK, 36; and the middle girt, LM, 59?

Here $(A B) = 370 - (A o) = 160 = (O B) = 210$; Then

Upper Section.		
Tab. area for	77	1·7016
circumferences,	54	·8369
No. 41.	67 = $1·2883 \times 4 =$	5·1532
		7·6917
		160
		6)1230·6720

Content of upper section 205·1120

Lower Section.		
Tab. area for	77	1·7016
circumferences,	36	·3719
No 41.	59 = $·9905 \times 4 =$	3·9620
		6·0355
		210
		6)1267·4550

Content of lower section 211·2425

And $205·112 + 211·2425 = 416·3545$ gallons total content.

In this case the vessel is supposed to be full and the dimensions taken outside, an allowance being made for the thickness of the wood.

Casks and other vessels with unequal ends may be measured in the same way; thus:—

(16.) What is the content of a cask in the form of a double prismoid, the greater head diameter, EF, (see preceding figure), being 32; the middle of that section, GH, 34·8; bung, or greatest diameter of the whole vessel, CD, 36; the middle diameter of the other section, LM, 33·3; its head, IK, 27; the length, A o, 18·4; and o B, 26·6.

Upper Segment.		
Tab. area for	36	3·6710
diameters,	32	2·9005
No. 30.	34·8 = $3·4303 \times 4 =$	13·7212
		20·2927
		18·4
		6)373·38568

Content of upper segment 62·23094



sum, and multiply by one sixth of the length; or multiply by the whole length, and divide by six times the square or

Lower Segment.			
Tab. area for	{ 36		3·6710
diameters,	{ 27		2·0649
No. 30.	{ 33·3 = 3·1410 × 4		12·5640
			18·2999
			26·6
			6)486·77734

Content of lower segment 81·12955

Then, 62·23094 + 81·12955 = 143·36049 gallons total content.

The areas may be found upon the Sliding Rule by the lines D and C, as in p. 112.

The two foregoing examples are from Todd, who states that the problem has been used by him for upwards of 20 years. His areas are taken from a Table of Sectional Areas, being one-sixth of the circular areas, which saves the trouble of dividing by 6, as in the foregoing operation. A further extension of this Rule is given under the head "Coppers," *infra*. In fact, it is applicable to curvilinear bodies, whatever be their length or irregularity, provided a sufficient number of middle diameters are taken, so as to divide the body into a proper number of frustums or prismoids. It is, in short, the same rule in principle, applied to solids, as the rule for measuring superficies by ordinates, namely, to take the sum of the areas of the extreme diameters, twice the areas of the odd diameters, and 4 times the areas of the even diameters; and multiply the same by one-third of the common distance between the diameters; or, which is the same thing, multiply by the whole length, and divide by three times the number of sections into which the vessel is apportioned (p. 94); thus:—

(17.) Let a cask or vessel be divided into eight sections by nine diameters, namely; top, 80, 83, 86, 88, 90, 89, 87, 84; bottom, 81; depth, 96; what is the content?

By Table of Circular Areas.

Extremes	{ 80 tab. area		18·1284
	{ 81 "		18·5844
Evens . .	{ 83 " 19·5135		
	{ 88 " 21·9354		
	{ 89 " 22·4367		
	{ 84 " 19·9866	83·8722 × 4	335·4888
Odds . .	{ 86 " 20·9496		
	{ 90 " 22·9438		
	{ 87 " 21·4397	65·3331 × 2	130·6662
Multiply by 96 (=depth) ÷ 24 (= 3 times the number of sections) =			502·8678
			4

2011·4712 gals. con.

If the two ends are alike, as in the case of a cask, the operation is in effect the same, although more simple (see Casks, *infra*), as in the following example:—

circular divisor; the product or quotient, as the case may be, is the content.

(18.) A cask measures 47 inches long, head diameter 26, bung 31, and the middle 29.3; what is the content?

$$\begin{aligned} 26^2 &= 676 \\ 31^2 &= 961 \\ 58 \cdot 6^2 &= 3433 \cdot 96 \end{aligned}$$

$$5070 \cdot 96 \times 47 \times \cdot 0004721 \text{ (fac. for round frus.)} = 112 \cdot 51 \text{ gals.}$$

By Table of Circular Areas.

$$\begin{aligned} 26 &= 1 \cdot 9148 \\ 31 &= 2 \cdot 7221 \\ 58 \cdot 6 &= 9 \cdot 7289 \end{aligned}$$

$$14 \cdot 3638 \times 47 \div 6 = 112 \cdot 5164 \text{ content.}$$

By the Sliding Rule.

$$46 \text{ (G P for round frus.) on D : 47 on C :: } \left\{ \begin{array}{l} 26 \\ 31 \\ 58 \cdot 6 \end{array} \right\} \text{ on D : } \left\{ \begin{array}{l} 15 \\ 21 \cdot 3 \\ 76 \cdot 2 \end{array} \right\} \text{ on C } \left\{ \begin{array}{l} 112 \cdot 5 \text{ gls.} \end{array} \right.$$

EXAMPLES OF THE WEDGE.

(19.) A vessel in the shape of a wedge, measures 8 inches along the edge; the base is 12 inches long, and 4 thick; and the perpendicular height 18 inches; what is the solid content?

$$\text{Top} \dots 8 \times 0 = 0$$

$$\text{Bottom} \dots 12 \times 4 = 48$$

$$\text{Sum} \dots 20 \times 4 = 80 \quad 128 \times 3 (= 18 \div 6) = 384 \text{ cubic inches. Ans.}$$

(20.) Suppose a quantity of malt be disposed in the form of a wedge; its height, C D, being 8 inches; the breadth of the base, A E, 20; its length, E H, 40; and its edge, C G, 20; what is the content in bushels?

$$20 \times 0 = 0$$

$$40 \times 20 = 800$$

$$60 \times 20 = 1200 \quad 2000 \times 8 \times \cdot 0000751$$

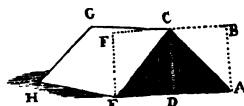
$$(\div \cdot 000451 \div 6) = 1 \cdot 202 \text{ bushels.}$$

By the Sliding Rule.

$$8 \text{ (height) on MD : } \left\{ \begin{array}{l} 40 \\ 60 \end{array} \right\} \text{ on B :: } 20 \text{ on A : } \left\{ \begin{array}{l} 2 \cdot 88 \\ 4 \cdot 33 \end{array} \right\} \text{ on B } \left\{ \begin{array}{l} 7 \cdot 21 \div 6 = 1 \cdot 2 \text{ bushels.} \end{array} \right.$$

If the perpendicular or slant height of a wedge cannot be conveniently measured, the perpendicular height may be found by extracting the square root of the difference between the square of the slant height, and the square of half the breadth. And the slant height may be obtained by extracting the square root of the sum of the square of the height, and the square of half the breadth.

If, in the foregoing example, the length of the edge had been equal to that of the base, the wedge would evidently have been equal to half a prism of the same base and altitude, and might have been measured by multiplying the length, breadth, and depth together, and taking one half of the product. In practice, such a wedge as the one last referred to, would be measured by finding the perpendicular height, C D, and the bases A E and E H, and taking half of their continual product for the content. If the ends and one side were against walls, the wedge would only be sloping on one side, but would be measured in the same way, taking A D for the base, and C D at the wall for the perpendicular height.



IV. THE FIVE REGULAR BODIES.*

A *Regular body* is a solid, bounded by similar and regular planes and angular figures. Of these there can only be five, namely:—the *Tetraedron*, contained by four equilateral triangles; the *Hexaedron*, contained by six squares; the *Octaedron*, contained by eight triangles; the *Dodecaedron*, contained by twelve pentagons; and the *Icosaedron*, contained by twenty triangles.

To find the content.—Multiply the cube of the linear edge by .11785 for a tetraedron, 1. for a hexaedron, .4714 for an octaedron, 7.66312 for a dodecaedron, and 2.18169 for an icosaedron; the product is the content.

V. SPHERES.†

A *Sphere*, or globe, is a round solid, every part of which is equally distant from a certain part within it, termed its centre.

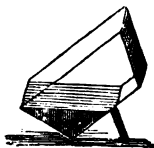
(21.) If the ungula or drip of a vessel assumes the form of a wedge, and measures 35 inches length of base, 15 breadth, 40 edge, and 18 perpendicular height, what is the content of the wedge in gallons?

$$40 \times 0 = 0$$

$$35 \times 15 = 525$$

$$75 \times 15 = 1125 \quad 1650 \times 3 \times .003606 = 17.85 \text{ gals.}$$

For an example of an ungula or drip of a conical vessel, see *Ungulas, infra*.



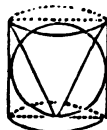
The content of a wedge may also be found by either of the following rules:—
I. To the length of the edge add twice the length of the base; multiply that sum by the height, and by the breadth of the base, and one sixth of that product will be the content. II. To twice the length of the base, add the length of the edge, and multiply the sum by the breadth of the base, and by one-sixth of the height; the product will be the solid content.

* To find the superficies of any regular body, multiply the square of the linear edge of the solid by 1.73205 for a tetraedron, 6 for a hexaedron, 3.46410 for an octaedron, 20.64578 for a dodecaedron, and 8.66025 for an icosaedron. The Tetraedron is an equilateral triangular pyramid (p. 107), and the hexaedron is a cube (p. 100).

† A sphere is generated by the rotation of a circle or a semicircle upon one of its diameters. One half of a sphere is called a hemisphere. The diameter of a sphere is any right line passing through the centre and terminated both

To find the content.—I. Find the area of a circle in the middle of the sphere; multiply it by two-thirds of the height; the product is the content.*

ways by the surface. The surface of a sphere is equal to the product of the circumference and diameter of the generating circle; that is, to four times the area of one of its great circles. The surfaces of spheres are as the squares of their semi-diameters, and their solid contents are as the cubes of their semi-diameters. Hence, if the diameter of a sphere be 1, its circumference and superficial content are equal, namely, 3.141592 (being 4 times the area of a circle of the same diameter); and if the diameter be 6, the solidity and superficial content are equal, namely, 113.097312. The solid content of a sphere is to that of a cylinder, of equal base and altitude (the diameter of the base of the cylinder being equal to that of the sphere), in the proportion of *two to three*; and to that of a cone of equal base and altitude, as *two to one*. These beautiful relations were discovered by Archimedes. A sphere being two-thirds of its circumscribing cylinder, the divisors for finding its content will be $\frac{2}{3}$ or one half greater than the circular divisors, viz., for gallons 529.554 (= 353.036 $\times 1.5$), and for bushels 4236.435 (= 2824.29 $\times 1.5$). The factors are the reciprocals, and the gauge points the square roots of the respective divisors. (See Table 30, in the Appendix.)



* EXAMPLES OF A SPHERE.

- (1.) What is the content in gallons of a sphere whose diameter, A B, is 12.5 inches?

By Rule I.

Constant factor (p. 87) $\cdot 7854 \times 12.5^2 \times 8\frac{1}{2}$ ($= \frac{2}{3}$ of 12.5) = 1022.65625 inches. Then $1022.65625 \div 277.274 = 3.68825$ gals. content.

Or $12.5^3 \times 8\frac{1}{2} \times .002832$ (cir. fact. for G.) = 3.68 gals. content.

By Rule II.

$12.5 \times 12.5 \times 12.5 \times .5236$ (sph. factor) = 1022.65625 = 3.68 gals. content. Ans.

By the Sliding Rule.

23 (spherical g. p.) on D : 12.5 on C :: 12.5 on D : 3.69 gals. on C.
For the gauge point for inches, bushels, &c., see Table No. 30.

By Table of Circular Areas.

Tab. area of diameter 12.5 = $.4425 \times 12.5 \times 2 \div 3 = 3.6875$.

- (2.) The diameter of a sphere is 20 inches; what is its content in gallons?
 $20^3 \times .0018884 \times 20 = 15.1072$ gals. Ans.
- (3.) What is the content of a sphere, whose circumference is 39.2699 inches?

By Rule III.

Find the diameter, by dividing the circumference by 3.1416 or by Table 34 = 12.5. Then $12.5 \times 39.2699 \times 2.0833$ ($= 12.5 \div 6$) = 1022.637 inches = 3.6882 gallons, as above.

Or the content may be obtained without reference to the diameter, by the Table of the Areas of Circumferences, No. 41; by multiplying the tabular number by the circumference, and dividing the same by 4.7124 (being $\frac{2}{3}$ or $1\frac{1}{2}$ of 3.1416, the divisor for reducing circumferences of circles to diameters); or multiplying it by .2122 (being two-thirds of .31831, the corresponding factor). By the Sliding Rule the content may be found in gallons as follows: $40.8 = (\sqrt{1663.6468} = 529.554 \times 3.1416)$ on D : circumference on C :: circumference on D : content on C,



II. Multiply the cube of the diameter by two-thirds of the circular factor ; the product is the content.

III. Multiply the diameter by the circumference, and by one-sixth of the diameter ; the product is the content.

VI. SPHERICAL SEGMENTS AND ZONES.*

A *Segment* of a sphere is any portion of a sphere, which is cut off by a plane ; and the circle in which the plane cuts the sphere is called the base of the segment. A *Zone* or *Frustum* is a part intercepted between two parallel lines, and is therefore the difference between two segments. When the ends or planes are equally distant from the centre on both sides, the solid is called a *Middle Zone*.

To find the content of a spherical segment.†—To three

* A sector of a sphere has a right cone added to the segment. Every section of a sphere by a plane is a circle. If one half of the diameter of a spherical segment be squared, and the product divided by the altitude, the quotient will give the altitude of the other segment. The semi-diameter of a segment is a mean proportional between the two parts of the diameter of the circle into which it is divided by the intersection of the diameter of the segment. The diameter of a sphere, of which any segment forms a part, is found by dividing the square of half the base, by the altitude of the *Frustum*, and adding to the quotient the altitude.

† EXAMPLES OF THE SEGMENT OF A SPHERE.

(1.) What is the content of a spherical segment, the diameter of the circular base being 36 inches, and the height 15?

$$18 \text{ (rad.)}^2 \times 3 + 15^3 = 1197. \text{ And } 1197 \times 15 \times \cdot 5236 \text{ (Tab. 30)} = 9401.238 \text{ inches.}$$

(2.) What is the content, in gallons, of a copper, in the form of a segment of a sphere, the diameter of its base being 90 inches, and the depth 15 inches?

$$45 \text{ (rad.)}^2 \times 3 + 15^3 = 6300. \text{ And } 6300 \times 15 \times \cdot 0018884 \text{ (sph. fact.)} = 178.45 \text{ gals.}$$

By the *Sliding Rule*.

$$23 \text{ (sph. g. p.) on D : 15 on C :: } \left\{ \begin{array}{l} 45 \\ 15 \end{array} \right\} \text{ on D : } \left\{ \begin{array}{l} 57.4 \times 3 = 172.2 \\ 6.3 \end{array} \right\} \text{ on C } \quad 178.5 \text{ gals.}$$

By the *Table of Circular Areas*.

$$\begin{array}{l} 45 = 5.7359 \times 3 \quad 17.2077 \\ 15 = \dots \dots \dots 6373 \quad 17.845 \times 10 (= \frac{2}{3} \text{ of } 15) = 178.45 \text{ gals.} \end{array}$$



The content of a spherical segment may also be found by either of the following rules :—I. Multiply the difference between three times the diameter of the sphere, of which the segment forms a part, and twice the height of the segment, by the square of the height, and by the spherical factor. II. Add to the square of the diameter of the segment's base, twice the product of the

times the square of the radius, or half diameter of the segment's base, add the square of its height or depth; multiply the sum by the height or depth, and the product by the spherical factor; the last product is the content.

diameter of the sphere, of which the segment forms a part, and the height of the segment; multiply the sum by half the height of the segment and by the spherical factor, the last product is the content.

If it be required to find the area of a spherical segment at each inch of the depth, the diameter of the whole sphere must first be found by dividing the square of half the base by the altitude of the frustum, and adding the altitude to the quotient, as stated above. Then for the diameter of the segment, at any given inch of the depth subtract the given number from the diameter of the sphere, and multiply the remainder by the same given number; twice the square root of the product will be the diameter required. Having obtained diameters for the whole depth of the vessel, find the areas respectively answering to half the sum of every two contiguous diameters at the various depths. Then to 3 times the area of half the lowest diameter add the area of the depth; two-thirds of the sum will be the content of the segment at the bottom. Add now the second inch area to the content of this segment, the third to this sum, &c., up to the mouth of the vessel. Thus, in the foregoing example :— $(45^2 \div 15) + 15 = 150$, the diameter of the sphere. Then $150 - 1 = 149 \times 1 = 149$, square root $12.2 \times 2 = 24.4$ diameter at the first inch from the bottom. The other diameters are obtained in the same way. Then for the content of the segment at the bottom :

Tab. area of $12.2 (= 24.4 \div 2) = .4215 \times 3 = 1.2645$
 " 1 (depth) " .0028

$$1.2673 \times \frac{2}{3} = .8448 \text{ gals.}$$

			<i>Diam.</i>	<i>Mean.</i>	<i>Areas.</i>
150 — 15 = 135	$15 \times 15 = 225$	square root of which $\times 2 =$	90	88.6	22.2555
150 — 14 = 136	$14 \times 14 = 196$	"	87.2	85.8	20.8528
150 — 13 = 137	$13 \times 13 = 171$	"	84.4	82.8	19.4196
150 — 12 = 138	$12 \times 12 = 1656$	"	81.3	79.7	17.9927
150 — 11 = 139	$11 \times 11 = 1529$	"	78.2	76.5	16.5769
150 — 10 = 140	$10 \times 10 = 1400$	"	74.8	73.0	15.0947
150 — 9 = 141	$9 \times 9 = 1269$	"	71.2	69.3	13.6038
150 — 8 = 142	$8 \times 8 = 1136$	"	67.4	65.3	12.0783
150 — 7 = 143	$7 \times 7 = 1001$	"	63.2	60.9	10.5054
150 — 6 = 144	$6 \times 6 = 864$	"	58.7	56.3	8.9783
150 — 5 = 145	$5 \times 5 = 735$	"	53.9	51.1	7.3964
150 — 4 = 146	$4 \times 4 = 584$	"	48.3	45.1	5.7614
150 — 3 = 147	$3 \times 3 = 441$	"	42.0	38.2	4.1834
150 — 2 = 148	$2 \times 2 = 296$	"	34.4	29.4	2.4483
150 — 1 = 149	$1 \times 1 = 149$	"	Seg. 24.4	24.4	.8448

Total content in gals. 177.9213

The mean diameter is found by taking half the sum of the diameter found and the next lower one, and the areas are taken from the Table of Circular Areas, No. 40.

(3.) What is the content of the crown of a copper in the form of a spherical segment, the base being 76.8 and the depth or height 10 inches?

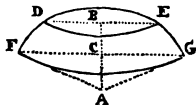
$$38.4 \text{ (rad.)}^2 \times 3 = 4423.68 + 10^3 = 4523.68,$$

$$\text{And } 4523.68 \times 10 \times .0018884 = 85.425 \text{ gals.}$$

To find the content of a zone or frustum of a sphere.*—
To half the sum of the squares of the top and bottom
diameters, add two-thirds of the square of the height ; multiply

* EXAMPLES OF THE ZONE OR FRUSTUM OF A SPHERE.

(4.) Let D E G F D represent the globular part
of a still in the form of a spherical zone or
frustum ; the top diameter D E being 30·7, the
lower diameter F G 104·1, and the altitude B C
15 ; required its content ?



$$30\cdot7^2 + 104\cdot1^2 = 11779\cdot30 \div 2 = 5889\cdot65$$

$$15^2 \times \frac{2}{3} = 150$$

$$6039\cdot65 \times 15 \div 353\cdot036 \text{ (or } \times \cdot002832) = 256\cdot564$$

[gals. content.]

By the Table of Circular Areas.

$$\begin{array}{r} 30\cdot7 = 2\cdot6896 \\ 104\cdot1 = 30\cdot6960 \end{array} \left. \vphantom{\begin{array}{r} 30\cdot7 \\ 104\cdot1 \end{array}} \right\} \div 2 = 16\cdot6828$$

$$15 = \cdot6373 \times \frac{2}{3} = \cdot4248 \quad 17\cdot1076 \times 15 = 256\cdot61 \text{ gals.}$$

If it be required to inch and tabulate the foregoing segment at every inch of the depth, proceed as follows :—First ascertain the diameter of the sphere, of which the segment forms a part, as follows : from the square of half the bottom or greater diameter F G subtract the sum of the squares of half the top diameter D E and the altitude of the frustum B C, divide the remainder by twice the said altitude, and the quotient will be the distance (C A) of the greater diameter from the centre of the sphere, the square of which, added to the square of half the greater diameter, gives the square of the semi-diameter G A ; thus :— $15\cdot35 \text{ (D B)}^2 + 15 \text{ (C B)}^2 = 480\cdot6225$. Then, $52\cdot05 \text{ (F C)}^2 = 2709\cdot2025 - 480\cdot6225 \div 30 \text{ (twice alt.)} = 74\cdot95266 \text{ (C A)} + 15 \text{ (C B)} = 89\cdot95266 \text{ (B A)}$. And $2709\cdot2025 \text{ (= C G}^2) + 5617\cdot9012 \text{ (= C A}^2) = 8327\cdot1037$, square of G A the semi-diameter.

The square of the semi-diameter being obtained, the segment is inched as follows :—To twice the difference of the squares of the semi-diameter (G A) and the distance A B diminished 1 inch, add half the square of the less diameter D E and two-thirds of the square of the first inch from the top, that is ·6666 ; this last sum, multiplied by the circular factor, gives the product of the first inch in gallons. Then, from the square of the semi-diameter G A, subtract the square of A B, diminished two inches, and from twice the remainder take half the square of the top diameter D E ; multiply the remainder by the circular factor and add the product to the quantity contained in the first inch for the content of the second inch. Let the product last mentioned be reserved, from which take ·02266056 (being 8 times the circular factor for a gallon, see demonstration in *Moss's Gauging*, p. 156), reserving the difference, which add to the quantity contained in the second inch ; the sum will be the quantity contained in the third inch. From the reserved difference take ·02266056, add the remainder to the third inch, the sum gives the quantity on the fourth inch ; and so on to the end. Thus :— $471\cdot245 \text{ (D E}^2 \div 2) + 2 [8327\cdot1037 \text{ (G A}^2) - 7912\cdot5757 \text{ (A B} - 1)^2] = 829\cdot056] = 1300\cdot301$. And $(1300\cdot301 + \cdot6666) \times \cdot00283257 = 3\cdot68508179 \text{ gals.}$ content of first inch.

Then, $8327\cdot1037 \text{ (G A}^2) - 7735\cdot6704 \text{ (A B} - 2)^2 = 591\cdot4333 \times 2 = 1182\cdot8666$. And $1182\cdot8666 - 471\cdot245 \text{ (D E}^2 \div 2) \times \cdot00283257 = 2\cdot01571799$. Reserved product to be added to the first inch for the content of the second :—

this sum by the height; divide the product by the circular divisor; the quotient is the content.

Reserved Product } Add to 1st Inch } Subtract . .	2·0157 ·0226	Content of } 1st Inch } Add .	3·6850 2·0157	Area of Inconbrance. .0113	Net Content. 3·6737
Add to 2nd Inch	1·9931 ·0226	2nd Inch	5·7007 1·9931	"	5·6894
Add to 3rd Inch	1·9705 ·0226	3rd Inch	7·6938 1·9705	"	7·6825
Add to 4th Inch	1·9479 ·0226	4th Inch	9·6648 1·9479	"	9·6530
Add to 5th Inch	1·9253 ·0226	5th Inch	11·6122 1·9253	"	11·6009
Add to 6th Inch	1·9027 ·0226	6th Inch	13·5375 1·9027	"	13·5263
Add to 7th Inch	1·8801 ·0226	7th Inch	15·4402 1·8801	"	15·4289
Add to 8th Inch	1·8575 ·0226	8th Inch	17·3203 1·8575	"	17·3090
Add to 9th Inch	1·8349 ·0226	9th Inch	19·1778 1·8349	"	19·1665
Add to 10th Inch	1·8123 ·0226	10th Inch	21·0127 1·8123	"	21·0014
Add to 11th Inch	1·7897 ·0226	11th Inch	22·8250 1·7897	"	22·8137
Add to 12th Inch	1·7671 ·0226	12th Inch	24·6147 1·7671	"	24·6034
Add to 13th Inch	1·7445 ·0226	13th Inch	26·3818 1·7445	"	26·3705
Add to 14th Inch	1·7219	14th Inch	28·1283 1·7219	"	28·1150
		15th Inch	29·8482	"	29·8369

Content of the Globular part 256·4710

Another rule for finding the content of any frustum of a sphere is to add the area of the top and bottom diameters to $1\frac{1}{2}$ area of the altitude, and multiply the sum by half the altitude; the product is the content; thus:—

$$30 \cdot 7 = 2 \cdot 6696$$

$$104 \cdot 1 = 30 \cdot 6960$$

$$15 \cdot = \cdot 6373$$

$$\frac{1}{2} = \cdot 2124 \quad 34 \cdot 2153 \times 7 \cdot 5 (= 15 \div 2) = 256 \cdot 61 \text{ content.}$$

M 2

VII. SPHEROIDS, SPHEROIDAL SEGMENTS, AND ZONES.*

A *Spheroid* is a curvilinear solid, which may be supposed to be generated by the revolution of an ellipsis about one of

By the Sliding Rule.

$$18.79 \text{ (IM G) on D : } 7.5 (=15 \div 2) \text{ on C :: } \left\{ \begin{array}{l} 30.7 \\ 104.1 \\ 15 \\ + \frac{1}{8} \end{array} \right\} \text{ on D : } \left\{ \begin{array}{l} 20. \\ 230.2 \\ 4.78 \\ 1.59 \end{array} \right\} \text{ on C } 256.57$$

(5.) Required the content of two separate spherical frustums (being portions of the top of a still), the top diameter of one of them being 10, bottom 18.1, and altitude 7; and the top diameter of the other 18.1, bottom 4, and altitude 8.

By Table of Circular Areas.

10 = .2832	18.1 = .9279
18.1 = .9279	4 = .0453
7 = .1387	8 = .1812
$\frac{1}{2}$ = .0462	$\frac{1}{2}$ = .0604
$1.3960 \times 3.5 = 4.886 \text{ gals.}$ $1.2148 \times 4 = 4.8592 \text{ gals.}$	

The foregoing rules apply to all spherical frustums. The content of the *middle frustum of a sphere* may be found as follows:—From the square of the axis, or greater diameter, subtract $\frac{1}{2}$ of the square of the height, and multiply the remainder by the height and by the circular factor. Thus:—

(6.) Required the content of the middle zone of a sphere of which the axis is 44 inches, and the height of the zone 14?

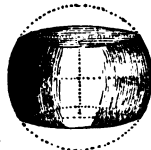
$$44^2 - \left(\frac{1}{2} \times 14^2\right) \times 14 \times .7854 = 20569.1024 \text{ inches} = 74.18 \text{ gals. Ans.}$$

Another rule, founded on the same principle, is the following:—Subtract $\frac{1}{2}$ of the circular area of the height from the area of the diameter, and multiply by the height; the product is the content. Thus:—

(7.) Required the content in gallons of the middle zone of a sphere of which the axis is 44 and the height 14 inches?

$$\begin{array}{rcl} \text{Tab. area of 44} & = & 5.4838 \\ 14 = .5551 \div 3 & = & .1850 \end{array}$$

$$5.2988 \times 14 = 74.18 \text{ gals.}$$



* A spheroid is equal to $\frac{2}{3}$ of its circumscribing cylinder, having the same base and altitude; and it is to the sphere what the ellipsis is to the circle. The difference between an oblate and prolate spheroid, will be best understood by considering the revolutions of a parallelogram. Suppose a parallelogram, 12 inches by 6, to be divided by two lines across the middle, at right angles to each other, so as to cut it into 4 equal portions, each 6 by 3. Then, if the parallelogram revolve on the shorter axis, it will generate a cylinder 6 inches deep, and having a diameter of 12 inches; consequently its content will be $6 \times 12^2 \times .5236 (= \frac{2}{3} \text{ of } .7854) = 452.3904 \text{ inches.}$ If it revolve on

its axes. If it revolve about its greater axis, the solid generated is called a *Prolate or Oblong Spheroid*; and if it revolve about the lesser axis, the solid is called an *Oblate Spheroid*. Any part of a spheroid cut off by a plane parallel to its axis is called a *Segment*; and what it wants of half the spheroid is called a *Frustum*. A portion consisting of two equal frustums on each side of the axis is called the *middle frustum* or *zone*; and when a cask assumes this form it is said to be of the *first* variety.

*To find the content of a spheroid.**—Multiply the square of the revolving axis by the fixed axis, and the product by the spherical factor; the last product is the content.

the longer axis, the cylinder produced will be 12 inches deep and 6 diameter, and its content $12 \times 6^2 \times \cdot 5236 = 226\cdot1952$; that is, in each case, the fixed axis multiplied by the square of the revolving axis, and by $\cdot 5236$; the content being much greater in the former case than the latter. (See *Kentish's Treatise*.) Vessels in the form of an oblate spheroid are never met with in gauging, but vessels in the form of the middle frustum of a prolate spheroid, are called *casks of the first variety*. This being the form in which casks are usually measured, much attention has been given to simplify and expedite the calculations for finding the content. The rule in the text is as concise as it can well be, except that in practice, instead of multiplying the area of the least base, and twice the area of the greatest, by one-third of the length, it is usually found most convenient to multiply by the whole length, and by one-third of the circular factor. It is important to observe that the factors, divisors, and gauge points, used for finding the content of a whole spheroid, are those used for *spheres* (p. 121); whilst for spheroidal frustums, those used for *cones* are employed (p. 107). So that for operations by the Sliding Rule, the gauge point for gallons applicable to spheroids is 23; and to spheroidal frustums, 32·54. For finding the content of spheroidal frustums, Woolgar's excellent line X may be conveniently brought into operation (p. 68). Or the content may be found by the tables of areas of Bung and Head diameters, Nos. 45, 46, in the Appendix, which are said to have been first introduced by Dr. Hutton.

* EXAMPLE OF A SPHEROID.

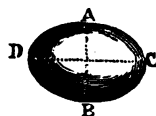
(1.) Required the content of a prolate spheroid, the revolving axis, AB, being 36, and the fixed axis, CD, 54 inches!

$$36^2 \times 54 \times \cdot 5236 = 36643\cdot 6224 \text{ inches} = \\ 132\cdot 1567 \text{ gallons.}$$

Instead of $\cdot 5236$, the spherical divisors or factors for gallons or bushels (Tab. 30) may be used.

The content of a spheroid may also be obtained as follows: Find the area of the circle, whose diameter is equal to the revolving axis, and multiply by the length, and take two-thirds of the product for the content; thus, in the foregoing example:—

$$\text{Tab. cir. area for } 36 = 3\cdot 6710 \times 36 (= \frac{2}{3} \text{ of } 54) = 132\cdot 156 \text{ gals.}$$



To find the content of the segment of a spheroid.—Find the spherical segment which has the same height and the same axis; then if the base be perpendicular to the fixed axis, the square of that axis is to the square of the other, as the spherical is to the spheroidal segment. But if the revolving axis be perpendicular to the base, that axis is to the fixed one, as the spherical is to the spheroidal segment.*

To find the content of the middle zone of a spheroid.†—

* EXAMPLE OF THE SEGMENT OF A SPHEROID.

(2.) The height of the segment of an oblong spheroid, of which the base is perpendicular to the fixed axis, is 16, and the axes are 48 and 38 inches; required the content?

$$3 \times 48 = 144$$

$$2 \times 16 = 32 \quad 112 \times 16^3 \times \cdot 5326 = 15012.6592.$$

$$\text{As } 48^3 : 38^3 :: 15012.6592 : 9408.97564 \text{ inches, } \times \cdot 003606 = 33.92 \text{ gallons content.}$$

If the vessel be an exact half of a *prolate* spheroid, the content may be obtained by multiplying the square of the diameter by the perpendicular height, and dividing by 529.554 for gallons, and 4236.434 for bushels.

Any diameter parallel to the base of a *prolate* semi-spheroid may be found as follows: To the altitude of the given vessel, add the distance between its base and the required diameter, and from the altitude subtract the said distance; multiply the sum by the remainder, and extract the square root of the product; then say, as twice the altitude of the given vessel is to the diameter of its base, so is twice the above root to the diameter required. (See *Nesbit and Little's Gauging*.)



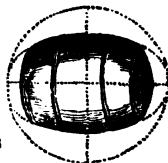
† EXAMPLES OF THE MIDDLE FRUSTUM OF A SPHEROID.

(3.) Required the content of the middle frustum of a spheroid in the form of a cask, of the first variety, the length being 40 inches, the middle, or bung diameter, 32, and the end, or head diameter, 24?

$$32^2 \times 2 = 2048$$

$$24^2 = 576$$

$$2624 \times 40 \times \cdot 000944 (= \cdot 002832 \div 3) = 99.08 \text{ gals. content.}$$



By the Sliding Rule.

$$\left. \begin{array}{l} \text{(By G. P.)} \\ \text{(p. 127).} \end{array} \right\} \begin{array}{l} 32.54 \text{ on D : } 40 \text{ on C :: } \left\{ \begin{array}{l} 24 \\ 32 \\ 32 \end{array} \right\} \text{ on D : } \left\{ \begin{array}{l} 21.8 \\ 38.6 \\ 38.6 \end{array} \right\} \text{ on C.} \end{array}$$

By the line { 24 on A : 32 on B :: 1 on B : 20.33 on X (g.p. for spheroid.)
(X, p. 70). { Then, as 20.33 on D :: 40 on C :: 32 on D : 99 on C.

By Table of Circular Areas.

$$\text{Tab. area of } 24 = 1.6315$$

$$\text{Ditto of } 32 = 2.9005$$

$$\text{Ditto do.} = 2.9005$$

$$7.4325 \times 40 \div 3 = 99.1 \text{ gals.}$$

To twice the area of the greatest base, add the area of the least base, and multiply the sum by one third of the length, and by the circular factor (or by the whole length, and by one third of the circular factor); the product is the content.

VIII. CONOIDS AND THEIR FRUSTUMS.

A *Conoid* is generated by the revolution of a curve about its axis, and it is called a *Parabolic Conoid*,* or a

By Table of Factors for Head and Bung Diameters, Nos. 45, 46.

Tab. area for head 24 = '5439

Tab. area for bung 32 = 1'9337

$$2'4776 \times 40 = 99'104 \text{ gals.}$$

In practice, although casks are measured as spheroids, it is usual to reduce them to cylinders, and find their contents as such, by the following old rule:—multiply the difference between the head and bung diameters when it is 6 inches or less, by '68, and when it exceeds 6 inches, by '7, and add the product to the head diameter; the sum will be a mean diameter between the head and bung, and may be used as the diameter of a cylinder, and the content found accordingly, either by the pen, or by reference to the Table of Circular Areas; such content in either case being, in the previous question, nearly a quarter of a gallon more than by the rule in the text. Thus, 32—24=8 × '7=5'6+24=29'6, the mean diameter. Then, 29'6² × 40 ÷ 353'036=99'271 gallons; or by Table 40; tab. No. 29'6=2'4817 × 40=99'2680 gallons.

To find the content by the Sliding Rule a line is marked called "spheroid," or "first variety," which gives the difference, calculated as above, to be added to the head diameter. On the head rod used at the Docks this spheroidal or first variety line is used with a line of inches in such a way as to show, at one setting, the differential sum to be added; and the amount, or mean diameter, after it is added.

If the diameter of a cask cannot be obtained, the circumference may be measured by a tape, and after making allowance for the thickness of the cask, the content may be found by the Table of Areas for circumferences, No. 41; thus:—

(4.) Suppose a cask, similar to the above, measure 106 inches round the bung, and 82 round the head, and 40 inches long; what is the content?

Deduct 6 inches from the bung and 5 from the head, for the thickness of the wood; then,

By Table of Circumferences.

$$82-5 = 77 \text{ tab. area} = 1'7016$$

$$106-6 = 100 \text{ tab. area} = 2'8700$$

$$2'8700$$

$$7'4416 \times 40 \div 3 = 99'221 \text{ gals.}$$

(5.) If a spheroidal vat be 46'6 inches head diameter, 50 bung, and 100 long, what is the content?

By Table of Areas for Head and Bung.

$$\text{Tab. area of head } 46'6 = 2'0504$$

$$,, \text{ bung } 50 = 4'7210$$

$$6'7714 \times 100 = 677'14 \text{ gals.}$$

* A parabolic conoid is equal to one half of its circumscribing cylinder, having

Hyperbolic Conoid, according as the generating curve is a parabola, or a hyperbola.

Any part of the conoid, cut off from the vertex by a plane perpendicular to the axis of revolution, is called a *Segment*, and what it wants of the whole conoid is called a *Frustum*. And if the frustums of two equal parabolic conoids are joined together at their greater ends they form a cask of what is called the *third variety*.

*To find the content of a parabolic conoid.**—Multiply the square of the diameter of the base by the height, and by half the circular factor; the last product is the content.

To find the content of the frustum of a parabolic conoid.†—

the same base and altitude, and a hyperbolic conoid is equal to $\frac{1}{2}S$, or as 1 to 2·4 of such circumscribing cylinder.

* EXAMPLE OF A PARABOLOID, OR PARABOLIC CONOID.

(1.) If the diameter of a parabolic conoid be 40 inches, and the height 30, what is its content?

$$40^2 \times 30 \times \cdot 3927 (=7854 \div 2) = 18849\cdot6 \text{ inches. Ans.}$$

The same rule will also give the content of the segment of a paraboloid.



† EXAMPLES OF THE FRUSTUM OF A PARABOLOID, OR PARABOLIC CONOID.

(2.) If the greatest diameter of the frustum of a parabolic conoid be 58 inches, the least diameter 30, and the height 18, what is its solid content?

$$(58^2 + 30^2) \times 18 \times \cdot 3927 = 30140\cdot5104 \text{ inches. Ans.}$$

(3.) If a cask in the form of two equal frustums of a parabolic conoid, the *third variety*, be 40 inches long, bung diameter 32, and head diameter 24, what is its content?

$$(32^2 + 24^2) \times 40 \times \cdot 001416 = 90\cdot624 \text{ gals. content.}$$

By the Sliding Rule.

$$18\cdot79 (\text{I M G}) \text{ on D : } 20 \left(\frac{1}{2} \text{ of } 40 \right) \text{ on C :: } \left\{ \begin{array}{l} 24 \\ 32 \end{array} \right\} \text{ on D : } \left\{ \begin{array}{l} 32\cdot6 \\ 58\cdot0 \end{array} \right\} \text{ on C} \quad 90\cdot6 \text{ gals.}$$

Also by the line X. (See p. 70.)

By Table of Circular Areas.

$$\text{Tab. area of head } 24 = 1\cdot6315$$

$$,, \quad ,, \quad \text{bung } 32 = 2\cdot9005 = 4\cdot5320 \times 20 (= \frac{1}{2} \text{ of } 40) = 90\cdot64 \text{ gals.}$$



The old method of finding the content of a cask of the third variety was, to multiply the difference between the head and bung diameters, when it was 6 inches or less, by ·55; and when it exceeded 6 inches, by ·57, and to add the product to the head diameter: the sum was taken as a mean diameter between those of the head and bung, and used as the diameter of a cylinder, and the content found accordingly. Thus, in the foregoing example, $32 - 24 = 8 \times \cdot 57 = 4\cdot56 + 24 = 28\cdot56$ mean diameter. Then $28\cdot56^2 \times 40 \div 353\cdot036 = 92\cdot418$ gallons, being nearly two gallons more than by the Rule in the text. To find the content by the Sliding Rule upon the same principle, a line was formerly marked, called *third variety*, which showed the difference to be added to the

Multiply the sum of the squares of the two diameters by half the height, and by the circular factor ; or multiply by the whole height, and by half the circular factor ; the last product, in either case, is the content.

*To find the content of a hyperbolic conoid.**—To the square of the diameter of the base, add the square of twice the diameter in the middle, between the top and bottom ; multiply this sum by the height, and by one-sixth of the circular factor ; the last product will give the content.

IX. SPINDLES AND THEIR FRUSTUMS.†

A Spindle is a solid, which may be supposed to be generated

head diameter ; but this line is disused in practice, casks being now all measured as spheroidal, and allowances made in the length when they vary from that figure. (See Casks, *infra*.)

* EXAMPLE OF A HYPERBOLOID OR HYPERBOLIC CONOID.

(4.) What is the content of a hyperbolic conoid, the diameter of the base being 104 inches, the diameter in the middle 68 inches, and the height 50 inches ?

$$104^2 + (68 \times 2)^2 = 29312 \times 50 \times \cdot 1309 = 191847 \text{ inches} =$$

If a vessel in the form of a frustum of a hyperboloid or hyperbolic conoid should be met with, its content may be found thus : Find a fourth proportional to the transverse, the conjugate, and the altitude, and subtract a third of its square from the sum of the squares of the radii of the bases ; the remainder multiplied by twice the altitude, and by $\cdot 7854$, will give the content.



† A parabolic spindle is equal to $\frac{8}{15}$ (or as 1 to $\cdot 875$) of its circumscribing cylinder, having the same base and altitude. The entire spindle is not often met with in revenue practice ; but as the middle frustum or zone of a parabolic spindle is the form commonly adopted for casks, considerable attention has been paid to the Rules for finding the content of this particular solid. Mr. Woolgar has prepared a Table (No. 47 in the Appendix), which has the effect of converting the frustum into a spheroidal one, when used in conjunction with Dr. Hutton's Tables of Areas of Head and Bung Diameters (Nos. 45, 46). This Table shows the areas of differences between the bung and head diameters, and is used for finding the contents of casks of the second variety, as follows :—From the sum of the tabular areas of the head and bung (Nos. 45, 46) take the tabular area of their difference (No. 47), and multiply the remainder by the length ; the product is the content in gallons. Woolgar's line X on the Sliding Rule is also particularly applicable to this description of casks (p. 69). Todd proposes to find a middle diameter by adding to the sum of the bung and head diameters half their difference ; the content may then be found by the General Rule in the text. The formula of the Sliding Rule, founded on this principle, he considers to be very convenient, as it enables us to use a *constant* gauge point, consisting of integers only, viz., 46, the gauge point for round frustums (p. 108 and Table 30).

by the revolution of a circle, or any one of the conic sections round an ordinate to its axis. If the generating curve be a circle, the solid generated is called a *Circular Spindle*; if an ellipsis, an *Elliptic Spindle*; if a parabola, a *Parabolic Spindle*; and if a hyperbola, a *Hyperbolic Spindle*.

Any part of a spindle cut off by a plane parallel to its axis is called a *Segment*, and what it wants of half the spindle is called a *Frustum*. And the middle frustum or zone of a parabolic spindle, forms a cask, which is said to be of the *second variety*.

*To find the content of a spindle.**—To the square of the diameter in the middle of the spindle add the square of double the diameter at one-fourth of the length (that is exactly between the middle and one of the ends); multiply the sum by the length, and the product again by $\cdot 1309$, the last product is the solidity, very nearly.

To find the content of the middle frustum of a parabolic spindle.†—To the square of the diameter at the end add

* EXAMPLE OF A SPINDLE.

(1.) What is the content of a spindle whose length is 20 inches, the greatest diameter 6, and diameter at $\frac{1}{4}$ of the length 4.74 inches?

$$\begin{array}{r} 6^2 = 36 \\ (4.74 \times 2)^2 = 89.8704 \end{array}$$



$$125.8704 \times 20 \times \cdot 1309 = 329.5287072 \text{ inches.}$$

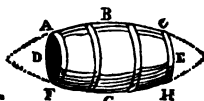
The content of a *parabolic spindle* may also be obtained in gallons and bushels by multiplying the square of the middle diameter by the length, and dividing that product by $\frac{1}{8}$ of the circular divisor, namely, by 661.943 for gallons, and 5295.543 for bushels.

To find the content of an *elliptical spindle*, divide three times the area of the generating segment by the length of the spindle, and from the quotient subtract the greatest diameter; multiply the remainder by four times the central distance, and subtract the product from the square of the greatest diameter; the remainder, multiplied by the length and by $\cdot 5236$, will give the content.

† EXAMPLE OF THE MIDDLE FRUSTUM OF A PARABOLIC SPINDLE.

(2.) The length, D E, of a vessel in the form of a parabolic spindle called a cask of the *second variety*, is 40, the greatest, or bung diameter, B G, 32, the least, or head diameter, A F, 24; required the content!

$$2(32^2) + 24^2 = 2624, \text{ and } (32 - 24 = 8 \times 2)^2 = 256$$



$$\begin{array}{r} \div 10 = 25.6 \\ \text{Then } 2624 - 25.6 = 2598.4 \times 40 \times \cdot 000944 (= \cdot 002832 \div 3) = 98.1 \\ \text{gallons content.} \end{array}$$

twice the square of the middle diameter ; subtract from the sum $\frac{1}{3}$ of the square of twice the difference between the two diameters ; multiply the remainder by the length, and by one-third of the circular factor ; the product is the content.

By the Sliding Rule.

By G P, for cones $\left\{ \begin{array}{l} 32.54 \text{ on D : } 40 \text{ on C :: } \left\{ \begin{array}{l} 24 \\ 32 \\ 16 \end{array} \right\} \text{ on D : } \left\{ \begin{array}{l} 21.8 \\ 38.6 \\ 9.0 \end{array} \right\} \text{ on C} \end{array} \right.$
 Then $99.0 (= 21.8 + 38.6 + 38.6) - 9 (= \frac{1}{3} \text{ of } 9) = 98.1 \text{ gals. Ans.}$
 By the line $\left\{ \begin{array}{l} 24 \text{ on A : } 32 \text{ on B :: } 1 \text{ on A : } 20.43 \text{ on X} \\ 20.43 \text{ on D : } 40 \text{ on C :: } 32 \text{ on D : } 98 \text{ on C} \end{array} \right.$

By Table of Head and Bung Diameters.

Tab. area for 32 bung . . . 1.9337 (See No. 46.)
 Tab. area for 24 head 5439 (See No. 45.)

2.4776

Tab. area for 8 difference . . .02417 (See No. 47.)

2.45343

40

98.18720 gallons content.

The old rule for measuring casks of the second variety was, to multiply the difference between the head and bung diameters, when it is six inches, or less, by .62; and when it exceeds six inches, by .64; and add the product to the head diameter; the sum will be a mean diameter between the head and bung, and may be used as the diameter of a cylinder, and the content found accordingly, either by the pen or by reference to the table of circular areas. Thus, in the previous question, $32 - 24 = 8 \times .64 = 5.12$, and $(5.12 + 24 = 29.12)^2 \times 40 \times .002832 = 96.058$ gallons; being two gallons less than by the rule in the text. Or by *Table of Circular Areas*: Tab. number $29.12 = 2.4019 \times 40 = 96.076$ gallons. To find the content by the *Sliding Rule*, there is a line usually called "Second Variety," which gives the difference, calculated as above, to be added to the head diameter; but this line is not much used at present; and in point of accuracy, Woolgar's Table is much preferable. In revenue practice, casks are now all measured as spheroidal, and allowances made in the length, when they vary from that variety. (*Vide Casks, infra.*)

The content of the middle frustum of a parabolic spindle may also be found by either of the two following rules:—I. Add eight times the square of the middle diameter, three times the square of the end diameter, and four times the product of those diameters, into one sum; multiply this sum by the length, and divide the product by fifteen times the circular divisor; the quotient is the content. II. To twice the square of the middle diameter, add the square of the diameter at the end, subtract from the sum four-tenths of the square of the difference between these diameters; the remainder, multiplied by one-third of the circular factor, and by the length, is the content. But the most comprehensive and accurate mode of measuring a cask, is by means of a diameter midway between the head and bung, as required by the general rule for spindles in the text (p. 134); which rule is in effect the same as that given for frustums (*ante*, p. 108).

To find the content of spindular frustums in general.—*
Add together the square of the top, the square of the bottom, and the square of twice the middle; multiply by the length, and by one-sixth of the circular factor; the product is the content.

X. UNGULAS.†

An *ungula* or *hoof*, is any part of a solid cut off, not parallel to the base. As the liquids in casks and other

* EXAMPLE OF SPINDULAR FRUSTUMS.

(3.) A cask in the form of the frustum of a spindle measures, head 24, bung 32, and diameter taken midway between them 30, and length 40; what is the content?

$$24^2 = 576$$

$$32^2 = 1024$$

$$60^2 = 3600$$

$$5200 \times 40 \times \cdot 000472 (= \cdot 002832 \div 6) = 98 \cdot 176 \text{ gals.}$$

By the Sliding Rule.

$$46 \text{ (cir. frus. G P. p. 131) on D : 40 on C :: } \left\{ \begin{array}{l} 24 \\ 32 \\ 60 \end{array} \right\} \text{ on D : } \left\{ \begin{array}{l} 10 \cdot 9 \\ 19 \cdot 3 \\ 67 \cdot 9 \end{array} \right\} \text{ on C.}^{\text{†}}$$

By Table of Circular Areas.

$$\text{Tab. area of } 24 = 1 \cdot 6315$$

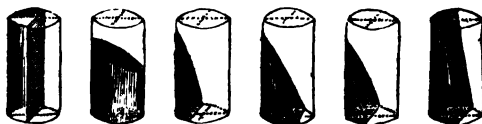
$$\text{" } 32 = 2 \cdot 9005$$

$$\text{" } 60 = 10 \cdot 1972$$

$$14 \cdot 7292 \times 40 \div 6 \text{ (p. 109) } = 98 \cdot 194 \text{ gals. Ans.}$$

The content of the middle frustum of a *circular* spindle may also be found as follows:—From the square of half the height of the spindle subtract one-third of the square of half the length of the zone, and multiply the remainder by half the length of the zone; find the area of the space which generates the zone, and multiply it by the central distance; subtract this from the former product, and twice the remainder multiplied by 3·1416 is the content.

† PRISMATICAL UNGULAS.



I. *When the section is parallel to the axis of the prism.*—Multiply the area of the base of the ungula by the height of the prism.

II. *When the section passes obliquely through the opposite sides of the prism.*—Multiply the area of the base of the prism by half the sum of the greatest and least lengths of the ungula.

vessels sometimes assume one or other of these forms when placed in an inclined position, the rules in the notes for ascertaining the contents of the most common varieties of them may be found useful.

III. *When the section passes through the base of the prism and one of its sides, and the height of the base is less than the radius.*—Find the area of the base of the ungula as the segment of a circle (see p. 88), and multiply it by the difference between the radius of the prism and versed sine or height of the ungula's base, and subtract the product from one-twelfth of the cube of the chord of the base; multiply the remainder by the height of the ungula, and divide the product by the height of the base.

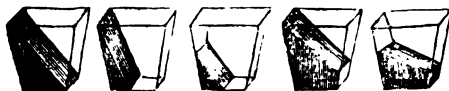
IV. *When the section passes through the base and one of the sides, and the height of the base is greater than the radius.*—Proceed as in the last rule, except that the product must be added to one-twelfth of the cube of the chord, instead of being subtracted from it.

V. *When the base of the ungula is an exact semicircle.*—Multiply the square of the diameter of the prism by the height of the ungula, and divide the product by 6.

VI. *When the section passes obliquely through both ends of the prism.*—Find the solidity of each of the ungulas by case III., and their difference will be the ungula required.

The above rules are more particularly applicable to cylinders, but the principles on which they are founded are common to prisms of every description.

PYRAMIDICAL UNGULAS.



I. *When the section passes through the opposite extremities of the ends of the frustum.*—This ungula is evidently a wedge, and the content must be found by the proper rule (p. 119). The empty part is also a wedge.

II. *When the section cuts part of the base of the frustum and reaches to the top on the opposite side.*—This ungula is also a wedge, and must be measured in the same way as before, its base being that part of the frustum's base only which it covers. The empty part of the frustum will, in this case, be a prismoid, the content of which may be found by the proper rule (p. 115).

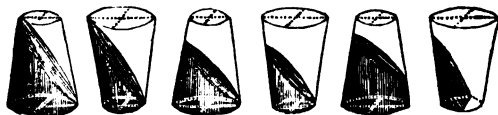
III. *When the section cuts part of the base of the frustum and does not reach to the top.*—In this case, also, the ungula is a wedge, and must be measured accordingly; the empty part will then be composed of a prismoid and a pyramidal frustum, or two prismoids.

IV. *When the section cuts one side of the frustum and rises obliquely to the top of the opposite side.*—In this case the ungula forms a frustum or prismoid and a wedge; and each section must be measured accordingly, and added together for the content of the ungula. The empty part is a wedge.

V. *When the section cuts opposite sides of the frustum.*—In this case the ungula consists of a wedge and a frustum, or prismoid, and the contents of each part must be found separately and added together for the content of the ungula. The empty part is also a wedge and a frustum, or prismoid.

To find the content of a vessel with an ungular drip or fall.—Find the content of the vessel (supposing it to be standing upright), according to the foregoing rules; then ascertain the part which will not hold liquor, by reason of*

CONICAL UNGULAS.



I. *When the section passes through the opposite extremities of the ends of the frustum, and the frustum stands upon the greater base.*—Multiply the product of the top and bottom diameters of the frustum by the mean proportional between them; subtract the last product from the cube of the bottom diameter; divide the remainder by the difference of the diameters; multiply the quotient by the perpendicular height of the ungula, and the product thence arising by one-third of the proper circular factor.

II. *When the section passes through the opposite extremities of the ends of the frustum, and the frustum stands upon its, less base.*—Proceed as in case I., except that the cube of the bottom diameter must be subtracted from the product above-mentioned, instead of the product being subtracted from the cube.

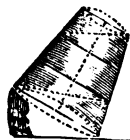
III. and IV. *When the section covers the lower base, but does not reach to the upper base.*—Proceed as in case I. or II., as the case may be, taking for the top diameter the diameter of the upper extremity of the ungula, measured parallel to the top of the frustum.

V. *When the section intersects opposite sides of the frustum.*—This figure evidently forms the frustum of a cone and an ungula, and the contents must be found separately and added together; or the content of the empty ungula may be found and subtracted from the content of the frustum, for the content of the other part.

VI. *When the section cuts only part of the base.*—Find the area of the quotient of the height of the base by its diameter, and multiply it by the cube of that diameter for the first content; from the height of the base subtract the difference between the diameters of the top and the base of the ungula; and find the area of the quotient of the remainder divided by the diameter of the top, and multiply it by the cube of the diameter at the top, and by the quotient of the height of the base, divided by the said remainder, and by the square root of the same quotient, for another content; multiply the difference of these contents by one-third of the height of the ungula, and the product, divided by the difference of the diameters, will give the content of the under ungula; and this ungula, subtracted from the content of the frustum, will give the content of the other ungula.

* EXAMPLE OF A VESSEL WITH AN UNGULAR DRIP.

(1.) Suppose a conical tun to be posited as in the annexed figure, and its dimensions as follows:—Top diameter of the vessel, 90; bottom diameter, 106; depth, 60; base of the ungula at the top, 94; and its perpendicular height, 10: what is the content of the vessel and ungula respectively, and how much will it hold in this position?



the inclining position of the vessel ; and subtract the one content from the other, for the content of the vessel in the inclined position.

XI. DISTILLERY VATS.

Most of the small vessels used by Distillers and other Excise traders, are either in, or can be reduced to the form of regular solids, rules for measuring which have been given in the foregoing sections. Many of the larger vessels used at distilleries are, however, of a doubtful form and curvature ;

First find the content of the whole vessel, as in p. 112, thus :—

Tab. area of 90	=	22·8438
Tab. area of 106	=	31·8267
Tab. area of 196	=	108·816

$$163\cdot5865 \times 10 (= 80 \div 6) = 1635\cdot865 \text{ gals. content,}$$

Then find the content of the conical ungula at the top of the vessel, by rule I. (p. 136), thus :—

$$\sqrt{(90 \times 94)} = 92; \text{ Then } 90 \times 94 \times 92 = 778320; \text{ And } 94^3 = 830584 - 778320 = 52264; \text{ Then } 52264 \div 4 (= 94 - 90) = 13066; \text{ And } 13066 \times 10 \times \cdot000944 (\frac{1}{8} \text{ of cir. factor}) = 123\cdot343 \text{ gallons, content of ungula.}$$

If this content be deducted from the content of the vessel, it shows the quantity the vessel will hold in this position, thus :—

$$1635\cdot865 - 123\cdot343 = 1512\cdot522 \text{ gallons.}$$

The perpendicular height of the ungula may be ascertained when the vessel is full, by means of a plumb line. To find the base of the ungula when the vessel is empty, some of the old writers recommend the use of a quadrant, which, being directed from the lower side of the upper base of the vessel, will carry the sight to a point on the opposite side, which may then be marked with chalk. (See *Dougharty's Gauging* (1739); *Leadbetter's Gauging*, 125.)

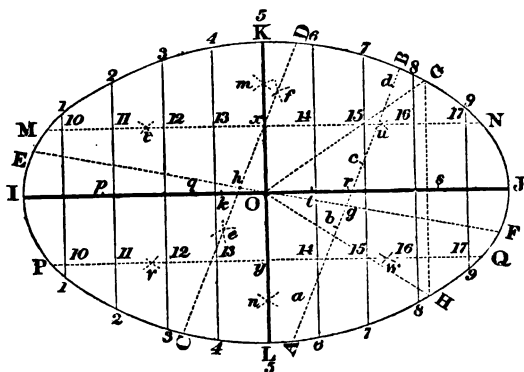
The usual method of gauging a vessel of this description is, to pour water into it from a known measure, until the bottom is just covered ; then let fall a plumb line to the surface of the water, which will give the perpendicular depth of the upper ungula ; which ungula is tabulated by means of cross diameters, according to the form in p. 113. It is evident, however, that the sections thus taken, parallel to the horizontal surface of the liquor covering the bottom, will not be circles, but ellipses ; but as the differences of their diameters will always be small (the figure in the margin being much more inclined than it is likely to be met with in practice), half the sum of the cross diameters are taken for a mean diameter, and they are then considered as reduced to circles, and the areas found accordingly. The chief difficulty in the tabulation is in regulating the dipping place. Whether for wet or dry inches, however, it may be most conveniently fixed at the top edge of the tun, so that the gauging rod, in taking the depth, may descend in a perpendicular direction near the side of the vessel.

For an example of an ungula or drip of a square vessel, see p. 120

their bases often approach to the elliptical form, but not near enough to allow of their being measured as ellipses; and their sides frequently bulge out irregularly in the middle or otherwise. Vessels of this description are measured by equidistant ordinates,* or cross diameters, according to one of the following rules.

To find the content of a large distillery vessel.†—Divide

* The rule for measuring the areas of elliptical figures by equidistant ordinates is given in p. 94. The following directions for applying it to gauging and tabulating distillery utensils, are re-produced from the Boards' instructions upon the subject, which it is understood were drawn up by G. Ballard, Esq., the under secretary.



† Let the above figure represent the base of an elliptical vessel, to be gauged by means of 9 equidistant ordinates 15 inches apart.

With a chalk-line strike a line A B in any part of the bottom; set off on this line two equal distances $a b$, $c d$; with centres a and b , and a radius of a suitable length, describe arcs cutting each other in e ; and with centres c and d , with the same radius, describe arcs cutting each other in f ; through the points $e f$ strike the line C D, and through the points $g h$ (the middle of the lines A B and C D) strike the line E F, the middle of which, O, will be the centre of the bottom of the vessel.

From the centre O, with a line of a suitable length, make two marks in the periphery of the bottom at G, H; strike the line G H, through the middle of which, and the centre, O, strike the transverse I J. Set off, from the centre O, two equal distances, $k l$; with centres k, l describe arcs cutting each other in m, n ; through these points and the centre, O, strike the conjugate K L. The bottom of the vessel being thus quartered, the distances I K, K J, J L, and L I will be equal, if the operations have been correctly performed.

On each side of the centre, O, on the line I J, set off any two equal distances $p q$ and $r s$; then from the centres p and q , and r and s , and any convenient

the base or bottom of the vessel into a sufficient number of ordinates, as directed in p. 92; draw lines from the extremities of the ordinates up the sides of the vessel; divide

radius (such as will make the distance of any two parallel lines something less than what you judge the least ordinates will be taken), describe arcs cutting each other in the points *t, u, v, w*, through which strike the lines *M N* and *P Q*, intersecting the conjugate diameter in the points *x* and *y* respectively. From the point *x* set off each way on the line *M N*, three, four, or more equal distances, according as it is intended to take seven, nine, or more ordinates, taking care that the distance between the extreme ordinates be something less (but as little as possible less) than the transverse diameter at the top of the vessel. With the same extent set off each way from the point *y* the same number of equal distances on the line *P Q*; that is, let the distances on the two lines be equal and parallel to each other: through the points 10 10, 11 11, &c.; strike the ordinates 1 1, 2 2, &c. Having divided the bottom and marked the ends of the ordinates with particular numbers, as 1, 1, 2, 2, 3, 3, &c., proceed to draw lines up the sides of the vessel as follows:—Hold a chalked plumb-line at the top of the vessel, so that the plummet falls on the ordinate 1 1; then, removing the plummet to the extremity 1, while the other end of the line is continued stationary, strike a line against the side of the vessel from the bottom to the top; proceed in like manner to strike lines from the extremities of every ordinate, and also of the transverse and conjugate diameters, from the bottom of the vessel to the top.

If the vessel be intended to be tabulated for *dry* inches, begin to mark out the distances and take the dimensions from the top, leaving the odd inches and tenths (if any) in the lower distance; but if for *wet* inches, begin from the bottom, leaving the odd inches and tenths (if any) in the upper distance, except the vessel has a curb or cover, through which the gauges must be taken; in such case, should the vessel be intended to be tabulated for *dry* inches, the thickness of such curb or cover must be deducted from the upper distance, and the dimensions taken in the middle of the difference, as exemplified in the table of dimensions given below. If the dimensions of the vessel at the top and bottom do not vary very considerably, they may be taken in the middle of every ten inches; otherwise they should be taken in the middle of every two, four, six, or eight inches, according as the sides incline to, or recline from, a perpendicular direction.

Previous to setting out these distances, the depth of the vessel should be ascertained. Having fixed upon and marked the proper dipping-place, let fall from it a plumb-line, and mark the spot on which the plummet falls; measure the distance between such mark and the dipping-place, and this distance will be the true depth of the vessel in the position in which it then stands. As the lines drawn from the shorter ordinates up the sides of the vessel will be oblique, care must be taken in marking the points from which the ordinates in the respective frustums are to be ascertained, that the lines measured from such points cut, at true distances from the top of the vessel, a perpendicular line, falling on the respective ordinates at the bottom of the vessel. The distances on the oblique lines may be ascertained as follows:—As the length of the perpendicular line is to the length of the oblique line, so are the respective distances from the top or bottom on the perpendicular line to the respective distances from the top or bottom on the oblique line. Or the true distances may be easily ascertained by trial, which is the method generally adopted.

If the vessel, the bottom of which is represented by the above figure, is to be tabulated for *dry* inches, let us suppose the dimensions to stand as in the

the sides of the vessel into portions of about 10 inches each, or smaller if the vessel be very irregular; measure and find

following Table, in which D is for depth, S sum of segments, T transverse, C conjugate, 1, 2, 3, &c., for the number of the ordinates taken, and In. for the incumbrance which is specified afterwards.

D.	T.	1	2	3	4	5	6	7	8	9	10	In.	Gr. Area.	Net Ar.	Content.
017	Curb or C. over														
083	1240	194	540	690	784	780	783	688	537	196	040		274565	256966	1027864
100	1261	247	558	700	786	800	782	705	559	248	061		274565	274565	1180629
100	1283	292	583	717	793	816	791	718	581	292	083		285679	285679	2286790
100	1302	319	598	733	804	828	805	736	598	317	102		295787	295787	2367570
100	1323	357	618	747	819	840	820	746	613	359	122		304400	304400	3044000
092	1340	408	627	763	829	862	830	761	628	410	140		314352	314352	3143520
011	Drip per Measure												324398	324398	2384461
603	Gross Depth.														240000
													Gallons Content.		17434834

Incumbrance—A beam inside the top.

L. 1220 } Inches :—Area 17599 gallons, to be deducted from the area of
D. 040 } the first four inches from the top.
D. 040 }

Before the last three columns of the foregoing Table can be filled up, the area of each frustum is to be found by the rule for ordinates in p. 94, and entered according to the following scheme :—

	1	2	3	4	5	6
Extreme Ordinates	194 196	247 248	292 292	319 317	357 359	408 410
x by sum of seg.	390 4	495 61	584 83	636 102	716 132	818 140
	156	30195	48472	64872	87352	11452
Even Ordinates	540 784 783 537	558 785 782 559	583 793 791 581	598 804 805 598	615 819 820 613	627 829 830 628
x by	2804 4	2684 4	2748 4	2805 4	2887 4	2914 4
	10416	10736	10892	11220	11468	11656
Odd Ords. excl. of ext. Ords. . . .	690 780 688	700 800 705	717 816 718	733 828 735	747 840 746	768 852 761
x by	2158 2	2205 2	2251 2	2296 2	2388 2	2376 2
	4316	4410	4502	4592	4666	4752
Even Ords. x by 4.	10416	10736	10892	11220	11468	11656
Sum of ext. Ords.	390	495	584	636	716	818
Equidistance (x by)	15122 15	15641 15	16076 15	16448 15	16860 15	17226 15
	226830	234615	241170	246720	252750	258390
Ext. Ords. x by sum of seg.	1560	30195	48472	64872	87352	114520
÷ by 831822 . .	228390	2376345	2460172	2532072	2614852	2696420
Areas of frus. in gals.	274565	285679	295787	304400	314352	324398

the area of each frustum according to the rule in p. 94 ; multiply each area by the depth of the part to which it belongs ; the sum of the products is the content.

The number designated the sum of segments, is the difference between the whole length of the transverse diameter, and that part of it inclosed between the two extreme ordinates ; or, in other words, it is the sum of the versed sines of the elliptical segments cut off by the extreme ordinates (marked in the figure 1 and 9). These segments, approaching very nearly to the form of parabolas, are considered as such ; and as every parabola is $\frac{2}{3}$ of its circumscribing parallelogram, the sum of the extreme ordinates, multiplied by the sum of the segments, and the product divided by three times the cubic inches in an imperial gallon, gives the same result as dividing $\frac{2}{3}$ of the product of each extreme ordinate and its versed sine, by the cubic inches in an imperial gallon (p. 95.)

Next, deduct the area of the incumbrance (if any) from the area affected by such incumbrance, and the difference will be the net area, which, multiplied by that part of the depth to which it belongs, will give the content of the frustum corresponding to such dimensions ; proceed in like manner for the content of the other frustums ; add together the respective contents, and also the quantity of liquor necessary to cover the bottom, and the total will be the whole content of the vessel.

The quantity of liquor required to cover the bottom of the vessel is ascertained by measuring into the vessel, with a known measure, a quantity sufficient to cover the bottom in every part ; the perpendicular depth of the liquor under the fixed dipping-place is also to be ascertained and subtracted, as also the thickness of the curb or cover (when the dry inches are to be taken above it) from the gross depth of the vessel, and the remainder will be the net depth to be tabulated.

The method in which the vessel is tabulated may be seen from the following specimen, extending to 6 inches from the top, and 6 inches from the bottom ; the intermediate inches, being tabulated in the same way, can be easily supplied, if necessary. The curb or cover, in this case, is supposed to be 1·7 inches thick ; and the gauges requiring to be taken from the top of it, the table, instead of beginning at full, must begin 1·7 inches above the upper part of the inside of the vessel, as follows :—

Dry inches.			Dry inches.		
Full at	01·7	1743·4834	54		192·6869
$\frac{2}{3}$ Upper area		7·7090			32·4398
	2	1735·7744	55		160·2471
		25·6966	56		127·8073
	3	1710·0778			32·4398
	4	1684·3812	57		95·3675
		25·6966	58		62·9277
	5	1658·6846			32·4398
$\frac{2}{3}$ 1st area	}	26·2245	59		30·4879
$\frac{1}{3}$ 2nd area			$\frac{2}{3}$ of Lower area		6·4879
	6	1632·4601	59·2 drip		24·000

To find the content of a small distillery vessel.—Take cross diameters at the top and bottom, and at different depths between them, and find the circular areas of each section; multiply each area by the depth of the section to*

The table of the vessel as entered in the Table Book is as follows:—

Dry Inches.	Gallons.	Area of a Tenth.	Dry Inches.	Gallons.	Area of a Tenth.	Dry Inches.	Gallons.	Area of a Tenth.	Dry Inches.	Gallons.	Area of a Tenth.
01·7	1743		16	1351		31	911		46	448	
2	1736		17	1323		32	890		47	417	
3	1710	2·569	18	1294		33	850		48	385	
4	1684		19	1265		34	819		49	354	
5	1659	1 ¹ / ₁₀ 2·569	20	1237		35	799	3·044	50	322	
6	1632	3 ³ / ₁₀ 2·745	21	1207		36	758		51	290	
7	1605		22	1178		37	728		52	257	
8	1577	2·745	23	1148		38	698		53	225	
9	1550		24	1119		39	667		54	193	
10	1523		25	1089	2·957	40	637		55	160	3·243
11	1494		26	1059		41	605		56	128	
12	1465		27	1030		42	574		57	95	
13	1437		28	1000		43	542		58	63	
14	1408		29	971		44	511		59	30	
15	1380	2·856	30	941		45	480	3·143	59·2	24	Drip.

In dividing the Table Book, a sufficient space should be appropriated for entering the dimensions of the whole of the utensils (and for such others as may be erected) before the commencement of the tables, showing the quantity of liquor each vessel is capable of containing at every inch of its depth.

Depths.

08·6

10·0

10·0

10·0

10·0

08·9

01·1 drip.

58·6 gross depth.

* EXAMPLE OF A SMALL DISTILLERY VESSEL.

Let the third figure in p. 104 represent the bottom of a circular distillery spirit receiver, to be gauged and tabulated for wet inches.

Find the centre of the bottom of the vessel, and divide the circumference into eight equal parts, according to the directions in p. 104. From the top of the vessel let fall perpendiculars on the diameters before struck, and from the extremities of the diameters to the points whence the perpendiculars were let fall, strike up the sides of the vessel the lines on or between which cross diameters are intended to be taken.



which it belongs; the sum of the sectional contents is the content of the whole vessel.

If, however, the vessel be small and very nearly circular, it will be sufficient to take cross diameters at right angles in the middle of each section, and the vessel may be expeditiously quartered by measuring the diameter at the top of the vessel, multiplying it by '707, and the product will be the side of the inscribed square nearly. Having by trial found the true side of the inscribed square, mark the angular points, from each of which let fall a plumb-line, and mark the spot where the plummet touches the bottom; strike a line across the bottom each way, so as to pass through the opposite marks, and the points where the ends of the lines touch the sides will correspond with the quarterings at the top. The vessel being thus quartered throughout, strike straight lines from the bottom quarterings to the top; and cross diameters may then be taken at any assigned distance from the top or bottom. Previous to setting out the distances on the sides of the vessel the depth should be taken. Having fixed upon and marked the proper dipping-place, let fall therefrom a plumb-line, and mark the point where the plummet touches the bottom of the vessel. Carefully ascertain the distance between the point so marked and the dipping-place, which distance will be the depth of the vessel in the position in which it then stands. Let the following represent the dimensions of the vessel to be tabulated for wet inches:—

Mr. A. B.'s spirit receiver, gauged 10th October, 1851, by C, D, and E, F:—

Depth.	Cross-Diameters.				Mean Diameters.	Incumbrance.		Gross Area.	Net Area.	Content in gallons.
	1	2	3	4		Depths.	Area.			
0·87	110·1	110·7	110·0	110·5	110·4	{ 04·2 04·5	1·4979	84·5238	83·0259	138·7087
10·0	112·0	112·4	112·1	112·5	112·2			35·6587	34·5238	155·8571
10·0	113·8	113·6	113·7	113·5	113·6			36·5542	...	365·5420
10·0	115·4	115·6	115·5	115·4	115·5			37·7871	...	377·8710
08·1	117·2	117·3	117·2	117·1	117·2			38·9077	...	384·0600
00·9	Drip per Measure									27·0000
48·7	Depth								Content...	1775·1258

Incumbrance—A beam across the top.

L. 109·3 } Inches—Area 1·4979 gallons to be deducted
B. 08·8 } from the Area of the first 04·2 inches from
D. 04·2 } the top.

The mean diameter is found by dividing the sum of the cross diameters by their number, adding a tenth if the remainder exceeds one-half of such number; otherwise the remainder is disregarded. Calculate the area of each segment as a circle, or find it in the table of circular areas, and deduct the incumbrance (if any), beginning at the bottom, as the vessel is to be tabulated for wet inches. The drip must be ascertained in the manner mentioned with respect to the drip of the elliptical vessel, observing, that though a vessel may stand horizontally, the quantity of liquor required to cover the bottom should be ascertained, as the bottom is never perfectly level.

XII. STILLS.*

A *Still* is a utensil or apparatus for distilling spirits, and usually consists of three parts, viz. 1. the body of the still,

The method of tabulation for wet inches will be understood by the following specimen, showing the first and last inches :—

Wet inches.	Wet inches.
Drip 0·9 27·0000	47 1718·9818
$\frac{1}{16}$ Lower area . . 3·8907	33·0259
1 30·8907	48 1752·0077
38·9077	$\frac{7}{16}$ Last area . . 23·1181
2 69·7884	48·7 1775·1258

Proceed in the same way to 46

In making this tabulation it is not necessary to write down the area at every inch; but only to enter it on a piece of paper, and move it downwards as we subtract or add, according as the table is for dry or wet inches. The result of the tabulation is entered in the Table Book as follows :—

Wet Inches.	Gallons.	Area of a Tenth	Wet Inches.	Gallons.	Area of a Tenth	Wet Inches.	Gallons.	Area of a Tenth	Wet Inches.	Gallons.	Area of a Tenth
00·9	27	drip	13	494		26	978		39	1445	
1	31		14	532		27	1015		40	1481	
2	70		15	570	3·778	28	1051	3·655	41	1515	
3	109		16	608		29	1088		42	1550	3·452
4	148		17	645		30	1124		43	1585	
5	186	3·890	18	683		31	1160		44	1619	
6	225		19	721		32	1196		45	1653	$\frac{5}{16}$ 3·452
7	264		20	759		33	1231		46	1686	$\frac{1}{16}$ 3·302
8	303		21	795		34	1267		47	1719	3·302
9	342		22	832		35	1303	3·565	48	1752	
10	381		23	868	3·655	36	1338		48·7	1775	
11	419		24	905		37	1374				
12	457		25	942		38	1410				

In this table as in the former example, when the decimal parts of a gallon amount to six-tenths, a gallon is taken, and any less fraction disregarded.

Had the vessel been gauged for dry inches, instead of setting out the distances from the bottom, and taking the dimensions in the middle of such distances, as in the preceding example, the distances must have been set out from the top, and the dimensions taken in the middle of such distances, the area of the incumbrance being deducted from the area of that part of the depth in which such incumbrance is placed.

Depths.

10·0

10·0

10·0

10·0

07·8

00·9 drip.

—

48·7 gross depth.

* The forms of stills vary so much that it is impossible to give any rules which

consisting of a copper or boiler, in which the wort is boiled for distillation ; 2. the still head, consisting of a spherical and curved dome or covering through which the spirit escapes in vapour ; and 3. the worm, or refrigerator, consisting of a serpentine apparatus, in which the spirit is cooled and condensed. The first and second parts only require to be gauged.

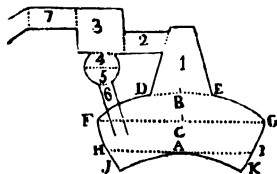
*To gauge a still.**—The lower part of the body of a still,

shall be applicable to the whole of them. Nesbit says, "Some writers on gauging affect to divide stills into different mathematical figures, and to find their contents accordingly ; thus the upper part of a still they suppose to form the frustum of a sphere ; the middle part, the frustum of a spheroid ; and the bottom they take as the segment of a sphere ; but it is more than probable that there never was any still made, the parts of which exactly corresponded to these figures ; consequently this method of gauging is subject to considerable inaccuracy. We have no hesitation in saying that the same method we have adopted in gauging coppers may be equally well applied in gauging stills. Still heads are also divided by the same writers into various mathematical figures, namely, the upper and lower parts are considered to form spherical frustums, and the middle part is taken as the middle frustum of a spheroid ; but we object to this method of division on the same ground as we do to that of the still. The content of a still head, at every inch of its perpendicular depth, is never wanted, but merely the content of the whole head ; hence we are of opinion that a more accurate and practical rule cannot be devised than that which we have given." (*Vide Coppers, infra.*) The example and directions which immediately follow are founded on the Board's Instructions ; but it is understood that in practice stills are usually gauged by filling them with water, and measuring the water either as it is put in or drawn out, and the quantity at every inch, &c., marked as the work proceeds.

* EXAMPLE.

(1.) Let the annexed figure represent the section of a still to be gauged. C being the body of the still, and 1, 2, 3, 4, 5, 6, and 7 the different portions of the head.

Take the true distance from the centre of the crown A to the centre of the top of the globular part B, and the internal depth A B will be obtained. From each side where the globular



part commences extend a line FG as a diameter, and measure the distance CA, which taken from AB, leaves BC the altitude of the globular part DEGF. Quarter the still at the bottom HI, and also at the altitude FG, by finding the inscribed square in each case as before directed with respect to a circular vessel (p. 142) ; then, in order to draw four chalk lines up the sides of the still, so that it may be every where truly quartered, proceed thus :—Stick about an inch of lighted candle on A the centre of the crown, and let the still be darkened at the top ; then a line being extended from F to H, will form a shadow on the side of the still, which trace with a piece of chalk. Proceed in the same way for the other three lines. Take cross diameters in the middle

when in the form of a round copper, must be measured by equidistant ordinates or cross diameters, according to the rules for gauging distillery vats. The upper part of the body, or lower part of the head when globular, must be

of every four, six, eight, or ten inches, according as the body of the still differs more or less from a cylindrical form, and find their respective areas, which, multiplied by their corresponding depths, will give their contents as cylinders, the sum of which added to the content of the globular part D E G F, and the quantity of liquor to cover the crown, will give the content of the body of the still D E K J D. (See p. 143.)

Every part above the body of the still as high as the steam can ascend, and until a declination takes place, is considered part of the head, and gauged accordingly. The dimensions of the several sections must be taken externally, and an allowance made for the thickness of the metal, when the head is not sufficiently large to admit of their being taken internally; and in either case the contents of the several sections must be ascertained by the rules laid down by mathematicians for finding the contents of solids or sections thereof, of the same form as the sections of the head of the still.

Let the following represent the dimensions of the head and body of the still.

Mr. A. B.'s Wash Still, gauged October 11, 1851, by C. D., E. F., and G. H.

Depths.	Cross diameters.		Mean Diameters.	Incumbrance,		Gross Area.	Net Area.	Content in gallons.	
	1	2		Depths.	Area.				
15.0 {	30.7 104.1	30.7 104.1	30.7 104.1	15.0	.0113	Globular.		256.4710	
08.5	107.8	106.4	107.1	00.5	.0113		{	32.4794	16.2397
				03.0	.4743			32.0164	96.0492
				04.0	.0113			32.4794	129.9176
				01.0	.0286	32.4621		32.4621	
10.0	102.6	108.4	108.0	10.0	.0286	30.0507	30.0221	300.2210	
10.0	92.6	92.0	92.3	06.4	.0286	{	24.1028	154.2579	
				00.6	1.3269		22.8045	13.6827	
				02.0	.0286		24.1028	48.2066	
				01.0	.0173		24.1141	24.1141	
Crown per measure.									
43.5	Depth.					Content . .		1148.6209	

Incumbrances to be deducted :—A round spindle or cylinder 42.5 inches, diameter 02.0, area .0113 gallon, to be taken from every part of the depth except the bottom inch.

One cross bar, length 107.0 inches, breadth 01.2, depth 03.0, area .4630 gallon, to be taken from the 26th, 27th, and 28th inches from the crown.

Two cross bars, each length 90.0 inches, breadth 02.0, depth 00.6, area 1.2983 gallon, to be deducted from the lower six tenths of the fourth inch from the crown.

Four upright bars, each length 21.0 inches, breadth 02.0, depth 00.6, area .0173 gallon, to be deducted from the lower 21 inches.

All other incumbrances, such as sweeps, chains, &c., immersed in the liquor, required to cover the crown.

measured as the segment of a sphere. The still head must be divided into sections, and measured according to the solids which they most nearly represent. If there be a drip

The head of the still is measured in different sections, as follows :—

1st Section—Frustum of a Cone. (See page 113.)

Inches.					Net Content in Gallons.
Top Diameter			Incumbrance.		
Bottom	.	.	Depth.	Area.	
Altitude	.	.	39'0	0113	56'7380

Incumbrance—A Spindle (or Cylinder), the whole Altitude, diameter 02'0 inches, area 0113 gallon.

2nd Section—A Cylinder. (See page 105.)

Circumference	.	.	37'0	Inches	. 8'5294
Diameter	.	.	11'7		
Altitude	.	.	22'0		

3rd Section—A Cylinder. (See page 105.)

Circumference	.	.	57'0	Inches	. 20'4138
Diameter	.	.	18'1		
Altitude	.	.	22'0		

4th Section—Frustum of a Sphere. (See page 126.)

Top Diameter	.	.	10'0	Inches	. 4'8823
Bottom do.	.	.	18'1		
Altitude	.	.	07'0		

5th Section—Frustum of a Sphere. (See page 126.)

Top Diameter	.	.	18'1	Inches	. 4'8600
Bottom do.	.	.	04'0		
Altitude	.	.	08'0		

6th Section—A Cylinder. (See page 105.)

Circumference	.	.	12'8	Inches	. 1'0872
Diameter	.	.	04'0		
Altitude	.	.	24'0		

7th Section—A Cylinder. (See page 105.)

Circumference	.	.	31'6	Inches	. 10'1952
Diameter	.	.	10'0		
Altitude	.	.	36'0		

Whole content of head 106'7059

Head 106'7059 + Body 1148'6209 = 1255'3268 Content of Still.

The method of inching that part of the body of the still below the globular part is the same as that already described for inching a distillery vat or wash back (p. 141). But to ascertain the quantity at every inch of the globular part, the square of half the diameter of the sphere corresponding to it must be found, and it may then be inched as the segment of a sphere. See the example corresponding to the globular part of the present still in p. 124, from which it will be seen that the content of such globular part is 256'4710 gallons, as stated in the above dimension table.

or crown, the content may be ascertained by pouring in water from a known measure. And after deducting the

The method of tabulating the still is the same as in other cases.

Commencing thus :—

Full	1148-6209
	3-6737
1	1144-9472
	5-6894
2	1139-2578

And ending thus :—

48	89-05705
$\frac{5}{10}$ of 9th area .	12-05705
48.5	77-0000
To cover the Crown 77	

The table of the still is entered in the table-book as follows :

Dry Inches.	Gallons.	Area of a Tenth.	Dry Inches.	Gallons.	Area of a Tenth.	Dry Inches.	Gallons.	Area of a Tenth.	Dry Inches.	Gallons.	Area of a Tenth.
Full	1149		12	976	2 460	24	602	$\frac{1}{10}$ 3 246 $\frac{1}{10}$ 3 002	35	281	
1	1145	367	13	950	2 637	25	572		36	257	
2	1138	568	14	922	2 811	26	542		37	233	2 410
3	1131	768	15	892	2 983	27	512		38	209	
4	1122	965	16	860	$\frac{1}{10}$ 3 247 $\frac{1}{10}$ 3 201	28	482		39	185	
5	1110	1 160	17	828	8 201	29	452	3 002	40	161	$\frac{1}{10}$ 2 410 $\frac{1}{10}$ 2 280
6	1097	1 352	18	796		30	422		41	137	$\frac{1}{10}$ 3 280 $\frac{1}{10}$ 2 410
7	1081	1 542	19	764	$\frac{1}{10}$ 3 201 $\frac{1}{10}$ 3 247	31	392				2 410
8	1064	1 730	20	731		32	362		42	113	2 410
9	1045	1 916	21	699	8 247	33	332	$\frac{1}{10}$ 3 002 $\frac{1}{10}$ 2 410	43	89	$\frac{1}{10}$ 2 410 $\frac{1}{10}$ 2 411
10	1024	2 100	22	666		34	305		43 5	77	2 411
11	1001	2 281	23	634	$\frac{1}{10}$ 3 247 $\frac{1}{10}$ 3 246	To cover the Crown ...					77

Stills in which gauges are taken, have usually a cylindrical tube fixed in the breast thereof, and elevated some inches above the top of the globular part, where the table commences; in such cases, instead of the table beginning at full, as in the preceding example, it must begin at the number of inches the top of the tube is higher than the top of the globular part, in the manner similar to that pointed out with respect to the curb or cover of the elliptical vessel. But where no such tube is fixed in the breast of the still, the gauges must be taken from the lower part of the man-hole, which is generally some inches below the top of the globular part, and the table commences at the quantity the still is capable of containing, as high as the lower part of such man-hole.

incumbrances, if any, the several contents are added together for the entire content of the still.

XIII. COPPERS.*

A *Copper* is a vessel used for heating liquids in Breweries, Distilleries, &c. It is frequently in the form of a regular solid, and can then be measured by the proper rule in the foregoing sections. Sometimes, however, coppers bulge out

Example.—Where the gauges are to be taken through a tube, the top of which is two inches above the top of the globular part of the still.

	Dry inches.	Gallons.
Full . . .	2 . . .	1149
	3 . . .	1145
		&c.

Example.—Where the gauges are to be taken from the lower part of the man-hole, five inches below the top of the globular part of the still.

	Dry inches.	Gallons.
Full to the bottom of the man-hole . . .		1110
	1 . . .	1097
	2 . . .	1081
		&c.

It sometimes happens that a still is too small to admit of a person getting inside of it to take the internal dimensions; in which case, the most eligible method of ascertaining the content of the body, is by filling it with water from a known measure. The content of the head may be ascertained by the method already described for ascertaining the content of that part of the still.

To find how much the still will contain at every dry inch from the gauging or dipping place, proceed as follows:—After having filled it with water to such dipping place, in the manner described, draw off the water into a known measure, until the surface of the water remaining in the still be one inch from the dipping place; deduct the quantity drawn off from the full content of the body of the still, and the remainder will be the content of the body of the still at one inch dry. Proceed in like manner to find the content at every dry inch, until the crown only remains covered; deduct the whole quantity drawn off from the whole content of the body of the still, and the remainder will be the quantity required to cover the crown.

The particulars of the content of the still, and a table of its capacity at every inch of its depth from the dipping place, may be entered in the table-book in a manner similar to that already described with regard to the still; the capacity of which was ascertained from its dimensions.

* The comprehensive rule in the text (No. I.) is stated in *Nesbit's Gauger* to be deduced from the method of equidistant ordinates, and it is in effect an extension of the excellent rule for frustums given in p. 108. It is introduced in this place as being more particularly adapted to coppers; but it is equally applicable to stills, still-heads, wash-backs, and other curved vessels used by distillers, brewers, &c. And by obtaining mean diameters or sides of the different sections, it can be used for elliptical and rectangular, as well as for circular vessels.

irregularly, and have convex or concave bottoms, technically called "rising" or "falling crowns." In many cases there is, likewise, a metal or wooden hoop round the mouth of the copper, and rising several inches above it, called a "curb."

I. *To find the content of a circular copper with curved sides, by means of any odd numbers of equidistant cross diameters.**—Find the areas of the different diameters, and to the sum of the extreme areas add twice the sum of all the odd

*EXAMPLES APPLICABLE TO RULE I.

(1.) Suppose a copper to be divided into four sections; the diameter A B being 57, C D 72, E F 80, G H 76, K L 65, depth 48; what is its content in gallons?

By Table of Circular Areas.

Extreme dia-	{ A B 57	9.2030
meters.	{ K L 65	11.9876
Odd diameter	E F 80 = 18.1284 × 2 =	36.2568
Even diameters	{ C D 72 = 14.6840 × 4 =	58.7360
	{ G H 76 = 16.3609 × 4 =	65.4436

181.6070

Depth 48 ÷ 12 (= 4, No. of sections × 3) = 4

726.4280 gallons.

When only five diameters are taken, as in this case, the measurement is in effect the same as that recommended for casks, in p. 117.

When the vessel is very deep, and its sides much curved, a greater number of equidistant diameters must be taken, as in the following example:—

(2.) Suppose a copper to be divided into 6 sections, measuring as follows:—Extreme diameters, bottom 124, top 144. Odd diameters 161 and 166. Even diameters 146, 164, 157. Depth 120 inches; required the content in gallons?

By Table of Circular Areas.

Extremes	{ 124	43.5536
	{ 144	58.7361
Odd . . .	{ 161 = 73.4230 } 151.4773 × 2 =	302.9546
	{ 166 = 78.0543 }	
Even . . .	{ 146 = 60.3790 } 206.3838 × 4 =	825.5352
	{ 164 = 76.1848 }	
	{ 157 = 69.8200 }	

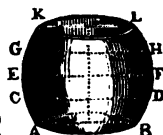
1230.7795

× (120 ÷ 6 =) common distance 20

3) 24615.5900

Content in gallons 8205.1966

If the vessel be very irregular, it must be measured by the rules for equidistant ordinates (pp. 92, 138).

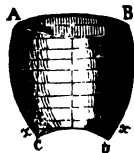


areas, and four times the sum of all the even areas ; multiply the total by the common distance between the diameters, and divide the product by 3 ; or multiply by the whole depth, and divide by three times the number of sections into which the vessel is divided ; the quotient, in either case, is the content.

II. *To gauge a copper with a rising crown.**—From the area corresponding to the diameter at the top of the crown subtract $1\frac{1}{2}$ of the area corresponding to the height of the crown ; multiply the remainder by half the height of the crown ; the product will show the quantity required to cover

* EXAMPLE APPLICABLE TO RULE II.

(3.) Let the annexed figure A B C D represent a copper with a rising crown, the diameter at the top of the vessel, A B, being 80 inches, and at the top of the crown, $x x$, 63·2 ; and at the base, C D, 54. Mean diameters, taken at 4 inches deep, 81·3 ; 13 inches deep, 82·4 ; 23 inches deep, 82·8 ; 33 inches deep, 83·2 ; 42 inches deep, 76·4 ; 49 inches deep, 72·7 ; 54·9 inches deep, 68·8 ; at 57·8 inches deep, (being the depth of the copper to the top of the crown,) 63·2 ; and the height of the crown 7·2 inches. What is the content ?



The content of that part of the copper which is above the crown, calculated by the Table of Circular Areas as directed in p. 150, is 1026·425 gals. Then to find the quantity of liquor to cover the crown,

Tab. area for diameter $x \times 63.2$	11.3139	
Do. for height of crown $7.2 = .1468$	} .1957	
$\frac{1}{2}$ of ditto		= .0489
		11.1182
$\times$ half height of crown		3.6

Liquor to cover the crown 40·02552 gals.

Then $1026\cdot425 + 40\cdot02552 = 1066\cdot45052$ gals., total content of copper.

Another mode of ascertaining the quantity of liquor to cover the crown is to find the content of C D, $x x$, as a frustum, as explained in p. 112, and of the arched part underneath the copper C D, as a spherical segment, as in p. 124 ; the difference of these contents is the quantity of liquor required. Or, if the altitude of the frustum be small, it may be reduced to a cylinder by finding its mean diameter, and the content found as in p. 104. But a more convenient and satisfactory way of proceeding is to pour into the copper as much water as will just cover the crown, and then draw off the water into a vessel of a known measure. The foregoing dimensions are from *Nesbit's Gauging*, in which it is stated, that the quantity found by admeasurement was 39 gallons ; being $\frac{1}{8}$ of a gallon less than by calculating the crown as a spherical frustum, and 1 gallon less than by the rule in the text.

To take the dimensions of a copper of this description, lay a straight pole or rod diametrically across the top of the copper, or, where that cannot conveniently be done, extend a small cord across it ; then along this rod or cord

the crown. The other part of the vessel may be measured and tabulated according to the rules already given.

III. *To gauge a copper with a falling crown.**—Find the content of the crown separately; the rest of the vessel may be measured and tabulated according to the rules already given.

move a line furnished with a plummet until the head hangs directly over the centre of the crown; the length of the plummet line will be the depth of the copper in the middle. Slide the plumb line along the rod above, till the ball touches the lowest part of the bottom of the copper; the distance the line has been shifted on the rod above is half the diameter of the rising crown, and the difference of the two perpendiculars is the altitude of the segment or height of the crown. Set off from the lowest part of the copper all round, a distance corresponding with the rise of the crown, and this will be the part for commencing to take cross diameters for measuring that part of the copper which is above the crown. Quarter the vessel from the top, and strike lines up the sides, and take cross diameters, as directed in p. 142.

* EXAMPLE APPLICABLE TO RULE III.

(4.) Let the annexed figure represent a copper with a falling crown, the diameter at the top, A B, being 108·9, and at the top of the crown C D, 76·8; the mean diameters, taken at 5 inches from the mouth, 112·1; at 15 inches, 109·9; at 25 inches, 103·3; at 35 inches, 99·8; at 45 inches, 93·9; and at 54·3 inches, 81·3; the entire depth of the vessel being 68·7, and the depth of the crown 10 inches.



The contents of the different sections may be found by multiplying the respective areas by the length of the sections, as in p. 143. And the content of the crown may be found by the rule for spherical segments in p. 122, thus:

$$\begin{array}{rcl}
 112\cdot1 & = & 35\cdot5952 \times 10 = 355\cdot952 \\
 109\cdot9 & = & 34\cdot2118 \times 10 = 342\cdot118 \\
 103\cdot3 & = & 30\cdot2260 \times 10 = 302\cdot260 \\
 99\cdot8 & = & 28\cdot2125 \times 10 = 282\cdot125 \\
 93\cdot9 & = & 24\cdot9753 \times 10 = 249\cdot753 \\
 81\cdot3 & = & 18\cdot7224 \times 8\cdot7 = 162\cdot884
 \end{array}$$

1695·092

$$(38\cdot4^2 \times 3) + 10^3 = 4523\cdot68 \times 10 = 45236\cdot8 \div 529\cdot554 = 85\cdot424$$

Total content in gallons 1780·516

The most convenient and satisfactory mode of finding the content of the crown, however, is by actual admeasurement.

To find the dimensions of a vessel of this description, lay a straight rod diametrically across the copper, and by the help of a plumb line find the perpendicular depth of the copper in the middle, and also at the sides, where the body of the copper and its crown are united; the difference of the perpendiculars will give the height of the crown, and the distance between the extreme perpendiculars will give the base of the crown. The vessel must be quartered from the top, and the cross diameters taken at proper intervals, the last section extending to the part where the crown is joined to the body (p. 142). When the concavity, formed by the falling crown, is very inconsiderable, it is usual to take a mean depth on the base, half way between the centre and side, and to take cross diameters at stated depths, disregarding the crown altogether.

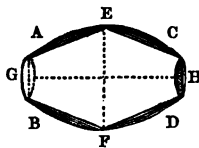
IV. *To find the content of a copper with a curb.**—Find the content of the curb separately; the rest of the vessel may be measured and tabulated according to the rules already given.

XIV. CASKS.

Casks are close circular vessels, bulging out in the middle and tapering towards the ends, which are flattened. They are of no exact geometrical form, and vary considerably in their different proportions. They have usually been divided into four different *varieties*† or classes, corresponding with

* The dimensions of a copper with a curb are taken, and the calculation made, as in the preceding examples, with this difference only, that the first pair of cross diameters are made in the middle of the curb, if the depth be an integral number of inches. If, however, the depth of the curb consists of inches and tenths, the tenths must be considered as belonging to the second division, and must be measured as part of the perpendicular height; consequently the odd tenths that may be in the whole depth of the copper will fall at the bottom, as they always should when the tabulation is intended for dry inches. (See *Neeble's Gauging*, 147.)

† All casks of whatever construction have usually been taken to constitute one of these varieties, and gauged accordingly. Thus, when a cask has been found to be much bent, or arching between the middle (or bung diameter) and the ends (or head diameters), it has been considered to be the middle frustum of a *spheroid*, or of the first variety. When the curvature between the middle and ends was found less arched or bent, the cask was considered to be the middle frustum of a *parabolic spindle*, or of the second variety. When the curve or arch between the middle and ends was very small, the cask was considered to constitute the lower frustums of two equal *paraboloids*, or to be of the third variety. And when there was no curvature at all between the middle and ends, the cask was considered to form the lower frustums of two equal *cones*, or to be of the fourth variety. It is, however, now generally admitted, that casks are seldom, if ever, found so much curved as the frustum of a spheroid, or so straight as two frustums of a cone; and *Moss* considers that there is never found so sharp an angle or ridge in the middle of any cask as there would be if it was formed of two frustums of a parabolic conoid. It is indeed evident, from an inspection of the figure, that the principal dimensions of any cask (as the head and bung diameters and length A B, C D, E F, and G H), may be exactly the same as those of another, yet, by reason of the curvature of the staves, the contents of the casks may differ from each other by a very large quantity. Besides the varieties mentioned in the text, others have been from time to time suggested. The variety ascribed to *Dr. Hutton* was made up of two of the others, the middle third being taken as of the second variety, and an equal portion on each end being of a conical form. *Dr. Young* recommended a form lying between the second variety and *Dr. Hutton's*. *Kentish* suggests a combination of the spheroidal and conical



the crown. The other part of the vessel may be *measured* and tabulated according to the rules already given.

III. To gauge a copper with a falling crown.*

content of the crown separately; the rest of the vessel may be measured and tabulated according to the rules

move a line furnished with a plummet until the head of the plummet touches the centre of the crown; the length of the plummet line touching the copper in the middle. Slide the plumb line along the crown until it touches the lowest part of the bottom of the copper. The distance has been shifted on the rod above is half the diameter of the crown, and the difference of the two perpendiculars is the height of the crown. Set off from the lowest part of the crown a distance corresponding with the rise of the crown for commencing to take cross diameters for measuring the crown which is above the crown. Quarter the vessel for the sides, and take cross diameters, as

* EXAMPLE APPLICATION

(4.) Let the annexed figure represent a falling crown, the diameter at the top, and at the top of the crown C D, 76.8 inches, taken at 5 inches from the crown, 109.9; at 25 inches, 103.3; at 45 inches, 93.9; and at 54.3 inches depth of the vessel being 68.7, and 10 inches.

The contents of the different parts, multiplying the respective areas by the height of the crown, and the content of the crown in p. 122, thus:

112.1 =
109.9 =
103.3 =
99.8 =
93.9 =
81 =

$$(38.4^2 \times 3) + 10^3$$

The most common

To find the diameter of the crown, perpendicular body of the vessel will be perpendicular from the crown. When used as a rule, it is



of the head and bung diameters, the cask will be greater than the middle frustum of a parabolic spindle, and therefore may be taken as a spherical frustum of the first variety. And if the distance (m n) be greater than half the difference of the two diameters, the cask, being less than a parabolic spindle, may be considered to be the middle frustum of a hyperbolic spindle. But the gauging of casks according to their different varieties, although it was ingenious, and even scientific, may now be considered as obsolete, there being in reality no such defined species of curve between the head and bung diameters as can be safely relied upon in practice.

* THE DIAGONAL ROD.

Upon this principle was constructed the Gauging Rod or Stick, from the

d m

, there
ould only
could be

solids are to
dimensions, the

that of a cylinder.

no common principle

, and no certain rule by

s can be distinguished from

the business of cask gauging the

Officer's duty; and the only

can be effected is, to treat all casks

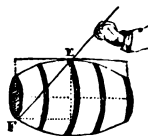
venue, only three dimensions are
 as of the *first variety*, or

and the sum will be the middle
 of a cask may also be
 rod; or by measuring the
 for the thickness of
 meter may be taken

inside, it is a *fourfold*

the diameter perfectly correct,
 since, by the nature of the
 to depend upon it in a *fourfold*

"ing" probably arose, and which is still used
 at accuracy is required. It
 of inches and tenths, and
 tenths, called a diagonal line; and
 the gauging of casks is easy, it being
 to insert the rod into the bung-hole in
 that the extremity of the rod may meet
 where it intersects the staves of the opposite
 the cask (as EF), and the content will be exhi-
 in gallons on the diagonal line, reckoning from
 the end of the rod to the centre of the bung-hole.
 In practice a diagonal is taken at each end of the cask, and if they do not
 agree, half the sum of the two dips is taken for the content.



The Diagonal Rod was probably constructed originally as follows:—The
 bung and head diameters and length of a cask, such as best agreed with the
 most general form of casks, were first carefully taken in inches and tenths,
 and its variety ascertained. Then the square of half the length was added
 to the square of half the sum of the bung and head diameters; and against
 the square root of that sum, measured on a straight rod, were placed the true
 contents of the cask in gallons. It is found by experiment that a cask con-
 taining 144 gallons has a diagonal of about 40 inches; therefore, 144 on the
 rod is placed at 40 inches; and since the contents are, as the cubes of the
 diagonals, $144 : (40^3 =) 64000 :: 114 : 50666\frac{2}{3}$, the cube root of which is
 37; therefore, 114 is put at 37; and in the same manner any other number
 of gallons may be placed upon the rod corresponding with the line of inches.
 This graduation, however, is rather higher than that marked on the diagonal
 rod in common use. It is given in the form of a table in the Appendix,
 No. 48, called the "Table of a diagonal line for Cask Gauging." By the use
 of this table a common cask may be gauged with a carpenter's rule and
 walking stick; for the length of the diagonal being taken in inches and
 tenths, the table will show the content in the column opposite to the number
 found. Nearly the same result would be produced by the pen, as follows:—
 To the square of half the length of the cask add the square of half the sum
 of the diameters, to get the square of the diagonal; this multiplied by its
 square root, and divided by $444\frac{1}{3}$, gives the content. It is, however, obvious,
 that as the calculation is only made for one particular kind of cask, its use
 must be very limited.

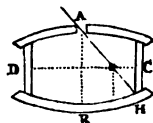
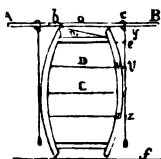
* See note on p. 157.

† The dimensions of casks are taken most readily with the callipers and

measure ; the great desideratum has therefore always been to find the content without this middle diameter.

bung and head rods. When these are not at hand Kentish recommends the following method to be adopted :—Procure a straight piece of deal, about $\frac{3}{4}$ of an inch square and 6 feet long, for a measuring rod, and with a camel's hair pencil and Indian ink, divide it into inches and tenths, [the Brannan's rule will of course answer as well, or better]. Then take another piece of deal A B, an inch square, and about 4 feet long ; and near the end A cut a notch ; and 2 inches from such notch at *b* make a mark. Then divide the distance from *b* to the end B into inches and tenths. Also procure two pieces of string each with loops at one end, and heavy plummets of lead at the other, and suspend one of them to the rod, A B, at the place where it is notched. Before tying the loop, on one of the strings slip on three pieces of cork, *e*, *v*, *z*, about $\frac{1}{8}$ of an inch thick and $\frac{1}{2}$ of an inch square. Then, to take the dimensions of a standing cask :—With a pair of compasses, or a piece of string and chalk, by prob. 3 in p. 74, strike a line across the middle of the head of the cask ; lay the rod A B over this line, so that the plumb line depending from the notched end may touch the bulge of the cask. Then slip the other plummet along to *c*, till it touches the cask in like manner. The number now cut by *c* will be the internal bung diameter C, the distance of two inches between the notch and *b* being an allowance for twice the thickness of the staves. With the measuring rod take the distance from *y* (the under side of the rod A B), to the ground *f*. Also the distance from *o* (the upper side of the rod), to *n*, the head of the barrel. Then *y f*, minus twice *o n*, will be the internal length of the cask ; the thickness of the square rod, A B, being supposed equal to the thickness of the head of the cask, which is generally one inch. The oblique line under the rod A B, measured from the inside of the chimb to the outermost sloped edge of the opposite stave, will be the internal head diameter ; or twice the distance at *e* may be deducted from the bung. To take the middle diameter D, slip the top cork up to *e* till the distance *y e* is equal to *o n*. The length of the cask being known, slip the second cork down to *v*, the distance *e v* being $\frac{1}{2}$ of the length ; in the same manner adjust the cork *z*, if necessary. Then add together the distances *v v*, *s z*, and subtract their sum from the bung diameter, or deduct twice the distance *v v* ; if the curve of the cask be uniform, the remainder will be the middle diameter D. In the same way might a diameter be taken between D and C. If only three dimensions be taken, the corks may be dispensed with.

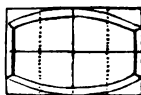
Symons, Moss, and others have given the following directions for finding the middle diameter of a cask internally :—Get a ring to fit your gauging rod so as to slide up and down at pleasure ; file a small notch in the inside of the ring for a plumb line to move up and down ; measure the diagonal A H, which suppose 37·7 inches ; then fix the ring and plumb line on the gauging rod at *o*, equal to half the diagonal, viz. 18·8. Put the rod again into the cask, and when the plummet touches the bottom take out the rod, holding the thread close to it, so that it may retain its position. Measure the perpendicular distance from *o* to the bottom of the vessel, which suppose = 17·1 ; this reserve. Then, from half the bung diameter subtract one fourth part of the difference between the head and bung diameters ; the remainder subtract from the reserved number ; add



In the practice of the Revenue, only three dimensions are taken; and all casks are considered as of the *first variety*, or

double the remainder to the head diameter, and the sum will be the middle diameter required, viz. 30·2. The middle diameter of a cask may also be obtained by boring a hole, and inserting a measuring rod; or by measuring the circumference at one fourth of the length, and allowing for the thickness of the staves; or if the end of the vessel be out, the diameter may be taken internally.

For taking the dimensions of a lying cask, a common pair of callipers may be made by any carpenter, something like two carpenter's squares sliding together (see p. 160.) Or it may be done by laying the cask horizontally on the ground, and placing a straight rod across it, and two others at right angles at each end, and then measuring the length, head, bung, and middle in the same manner as if it was standing, or as nearly as the circumstances will admit of, as shown in the diagram.



The general rule referred to in the text for finding the content of a cask by means of a middle diameter may be expressed as follows:—Add together the area of the head, the area of the bung, and four times the area of the middle diameter, and multiply the sum by one-sixth of the length; or add together the square of the head, the square of the bung, and the square of twice the middle (or the square of their sum, if they vary); multiply the total by the length and by one-sixth of the proper circular factor; the product in either case is the content. (See p. 114). Thus:—

(1.) Suppose the length of a cask be 40 inches, its bung diameter 32, its head diameter 24, and its middle diameter (p. 156), 30·2 inches, what is the content?

$$(32^2 + 24^2 + 60 \cdot 4^2) \times 40 \times \cdot 0004721 = 99 \cdot 106 \text{ gallons.}$$

Or, By the Table of Circular Areas.

$$\text{Middle diameter } 30 \cdot 2 = 2 \cdot 5834 \times 4 = 10 \cdot 3336$$

$$\text{Bung diameter } 32 \quad \dots \quad 2 \cdot 9005$$

$$\text{Head diameter } 24 \quad \dots \quad 1 \cdot 6315$$



$$14 \cdot 8656 \times 40 \div 6 = 99 \cdot 104 \text{ gals.}$$

By the Sliding Rule.

$$48 \text{ on D : } 40 \text{ on C :: } \left\{ \begin{array}{l} 24 \\ 32 \\ 60 \cdot 4 \end{array} \right\} \text{ on D : } \left\{ \begin{array}{l} 10 \cdot 9 \\ 19 \cdot 3 \\ 68 \cdot 9 \end{array} \right\} \text{ on C} \quad 99 \cdot 1 \text{ content.}$$

This result proves the cask to be of a spheroidal form, of which the middle diameter may at any time be found, by adding the square of the head diameter to three times the square of the bung diameter, and $\frac{1}{4}$ of the amount will be the square of the middle diameter required. Should the middle diameter, found by admeasurement, be less than the diameter found by this Rule, the cask is less than a spheroid. See another example in p. 119.

(2.) If the foregoing cask had been measured in the usual way for the head, bung, and length—the dimensions being as before—and the circumference in the middle had been found by measuring the cask externally (and allowing 6 inches for the thickness of the wood), to be 95; required its content?

$$24 \text{ by Table of Circular Areas } \dots \quad 1 \cdot 6315$$

$$32 \text{ ditto } \dots \quad 2 \cdot 9005$$

$$95 \text{ by Table of Circumferences, } 2 \cdot 5901 \times 4 \quad 10 \cdot 3604$$

$$14 \cdot 8924 \times 40 \div 6 = 99 \cdot 28$$

P

spheroidal form, an allowance or deduction being made in the length, so as to reduce the particular kind of cask to be measured to a spheroid as nearly as possible.* This necessarily leaves much to the judgment and experience of the gauger, and the practical officers usually consider that the requisite knowledge in this respect is to be acquired only by verbal instruction and observation. The Commissioners of

If the head and bung had been taken by circumferences, the areas might all be taken from the same Table; or if the circumferences respectively were divided by 3.1416, this would give the diameters, and then the areas might all be taken from the Table of Circular Areas.

Various rules have been given for finding a middle diameter without actual admeasurement. Amongst others, Todd gives the following:—"To the sum of the bung and head diameters add half the difference, the aggregate will be equal to twice the middle." Thus in the foregoing example, $24 + 32 + \frac{1}{2}(32 - 24) = 60 \div 2 = 30$, the middle diameter. But it is evident that those calculations can only apply to casks of one particular variety, and can never be of any great practical use (see p. 163). Nothing less than a *properly ascertained* middle diameter can be relied upon for all cases; but with this dimension, as Todd observes, the art of cask-gauging might be considered as reduced to the certainty of a science.

* The difficulty of obtaining a middle diameter, and of determining to what variety any particular cask belongs, has probably led to the practice referred to in the text, which, although not a very artistic mode of proceeding, is found to work better in the hands of an experienced gauger than might be expected. It is in fact a practical mode of bringing all casks to one standard by increasing or diminishing the length, and thus, as it were, producing a corresponding diminution or increase in the curvature. The rules in the text for taking the dimensions of casks and finding the contents, are founded on official directions issued for the guidance of the revenue officers at the ports. For the purpose of taking the dimensions, the officers are furnished with four instruments, viz., a pair of long callipers, a pair of cross-callipers, a bung-rod, and a head-rod, the use of which, respectively, will appear as the work proceeds. When there are a number of casks to be gauged upon the same attendance of the officer, they are required to be placed (particularly on the quays) in regular rows, with the bung-holes uppermost, and each cask exactly level and upright, and at such a distance from each other as to allow room for the play of the cross-callipers, and to admit the officer to pass freely between them. It must also be ascertained whether the bung-hole be in the middle of each cask, and that the bung stave, and the stave opposite to the bung-hole, are both regular and even within, and whether the heads of the cask are equal and truly circular. The order in which the dimensions are taken is not of much importance; but the usual practice is to find, 1st, the cross bung diameter; 2nd, the back head diameter; 3rd, the perpendicular bung diameter and wet inches; 4th, the length; and 5th, the cross diameters of the front head. A mean of each dimension is obtained (when more than one are taken) and chalked on the front part of each cask, from which the particulars are afterwards transferred to the officer's book, and the content and ullage of the casks are calculated from such dimensions. Each cask should be turned at least half over, and examined; and each tier cross and back-headed before the dimensions are taken.

Customs have, indeed, furnished their officers with tables of allowances for casks of different forms, and imported from different countries ; * but these are obviously intended to serve as general hints or suggestions only, and must be modified according to the actual and ever-varying forms of the casks coming under the officer's inspection.

To find the head diameter.—Place the lower edge of the crooked brass, which is on the end of the *head rod*, within the chimb of the cask close to the head, then move the slider till the brass index intersects the middle of the opposite chimb, about two-thirds up the chimb. This will give the internal head diameter of the cask on the lower line of the stock, directly opposite to the index on the slider.

To find the bung diameter.†—Lay the *cross callipers* over

* See Table 49, in the Appendix.

† If the cask appears fairly made, the mean of the horizontal and perpendicular may be taken for the bung diameter. Should two or three of the staves at the top or bottom of the cask appear flattened, and the rest of the cask circular, add to the perpendicular found as many tenths of an inch as the staves are considered to be depressed, and then take the mean for a bung diameter. If, on the contrary, two or three of the staves appear forced up so as to make what is termed a "cocked bung," or if the rod has little play at the bottom of the cask, deduct from the perpendicular found as many tenths of an inch as the case may seem to require before taking the mean for the bung. The bung diameter is taken both on the cross and dip, as if the staves of the cask were one inch thick, and this thickness must be deducted from the actual dimensions ; but in order to ascertain whether this is the real thickness of a cask of irregular formation (such as rum puncheons, brandy puncheons, madeira pipes, and other large sized casks), it is necessary to bore occasionally in the centre of the stave, at about one third distance from the head to the bung, and also the head in the piece next the centre, ascertaining the thickness with the wood gauge or graduated brass prepared for the purpose ; and should the stave be found to be more or less than an inch thick, the mean difference of the actual thickness must be added to or deducted from the dimensions found ; as in the following Examples :—

(3.) The staves of a rum puncheon on boring average eight-tenths of an inch. There is then too little upon the cross by two-tenths each stave, viz. $\cdot 4$, and upon the perpendicular $\cdot 2$, wherefore $\cdot 4 + \cdot 2 = \cdot 6 \div 2 = \cdot 3$, the mean to be added to the bung diameter, which was found according to the customary allowance of an inch for the thickness of the stave to be $32\cdot 1$; wherefore $32\cdot 1 + \cdot 3 = 32\cdot 4$, the true bung diameter of the vessel.

(4.) The staves of a madeira pipe average twelve-tenths thick. There is then too much upon the cross by $\cdot 4$ of an inch, and upon the perpendicular of $\cdot 2$; wherefore $\cdot 4 + \cdot 2 = \cdot 6 \div 2 = \cdot 3$, the mean to be deducted from the bung, which was found to be $28\cdot 7$; therefore $28\cdot 7 - \cdot 3 = 28\cdot 4$, the bung diameter to be charged.

Great care and precision are requisite in taking the bung diameter, it being double the value of the head ; and hence fraud is not unfrequently attempted

the bung-hole of the cask with their legs downward, and contract them until they touch the bulge of the cask on each side, when the external bung diameter will be shown on the stock of the callipers. Take two other horizontal diameters in other parts of the centre, and chalk the mean or average, as the cross, on the side of the bung, after deducting the thickness of the staves. With the bung rod examine the bottom and sides to ascertain if there are any irregularities in the staves or form, and make an addition or allowance accordingly; and deduct the thickness of the staves from the actual dimensions.*

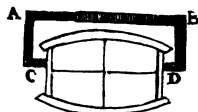
To take the length.†—Lay the *long callipers* over the bung-hole of the cask perfectly level, with the legs downwards, then contract them until their ends come in contact with the heads of the cask; first allowing the outer limb to touch the back head, and then bringing the inner one gently up to the front head, taking care not to press the rule. The length of the cask will then be shown on the stock, as the long callipers

to prevent the true dimensions being taken, which it is necessary for the officer to guard against.

* If the content of the cask is to be calculated according to the rule for the first variety, or middle frustum of a spheroid, which is the practice, as well in the excise as in the customs, a proper allowance or deduction must be made on the length so as to reduce the cask to the first variety. A table of the allowances, which it is usually necessary to make on the different kinds of casks, so as to reduce them to a spheroidal form, will be found in the Appendix, No. 49; but, for the reason already stated, this table can only be used to assist the officer's judgment, and must not be considered as official or permanent. Casks imported from different countries vary much in their form and construction, and it is therefore necessary to vary these allowances, and deductions accordingly. An allowance in or addition to the thickness of the head, as shown on the rule, must also be made, should it be found to exceed or be less than two inches.

† EXAMPLE.

(5.) Let the annexed figure represent a port pipe with the long callipers in the act of taking the length of the cask over the bung-hole, and suppose three lengths to be taken, namely, 49·2, 48·8, 48·7, and their sum $\div 3 = 48·9$ mean. Suppose it be considered necessary to add for the heads $(= 2·0 - 1·6) = 0·4$. Then $48·9 + 0·4 = 49·3$. And suppose it be necessary to deduct for the variety 0·6. Then $49·3 - 0·6 = 48·7$, the true length as charged. In practice, these calculations, being very simple, are made mentally, which facilitates the operation.



throw off two inches for the supposed thickness of the two heads. Take two other lengths, one on each side of the bung, so that the three lengths thus taken may be at equal distances from each other; divide the sum of these lengths by three for the mean length of the cask.

*To find the wet inches.**—Bring the lower end of the brass on the *bung rod* to the actual bung charged, if it be lowered, and after wiping the rule, redip it into the cask, taking care to hold the brass firm against the rule, that it may not be forced up, and the true wet will be shown upon the rod. If the bung be raised, there must be added to the wet inches shown as many tenths as it is raised.

To cast the content.†—Set the brass at the end of the sliding piece of the *head rod*, to the head diameter on the lower line of the rule; then look for the bung diameter on the same line, and observe what number it cuts on the middle line of the slider; find the same number on the lower line of the slider, and immediately under it on the lower line of the rule is the mean diameter. Set the brass on the upper

* The wet inches are to be taken as they are actually found in the cask, without regard to the cask having a flat top, or "cocked-up bung," because compressing the cask into the true form, supposed to be done by the allowance for the bung diameter, would neither raise nor depress the liquor in the body of the cask. If the bottom be flattened, there must be added to the wet inches shown upon the rod, the same number of tenths which have been added to the bung, as forcing the two staves into a circular form would not depress the liquor, although it would allow the bung rod to pass lower down, and consequently show a greater bung and wet. Spirits being subject to expansion, more or less, according to the different degrees of heat, an allowance is to be made upon the wet inches in hot weather from 4 to 5-tenths, and in moderate weather from 2 to 4-tenths, but nothing in cold weather. Upon wines, an allowance is generally made for the swell of the rule, in hot weather, 2-tenths, and at other times 1-tenth. (See p. 165.)

† This is in effect the rule for finding the content of the middle frustum of a spheroid by the Sliding Rule. The Head Rule is, in reality, a Sliding Rule; the lower part of the stock is a line of inches and tenths, and part of the lower line of the slider a *variety* line, to reduce a spheroidal frustum to an equivalent cylinder. The upper part of the stock is the line C, and the upper part of the slider is the line D. The operation on these lines will be seen by the following example, which is the same as that given as the middle frustum of a spheroid in p. 128.

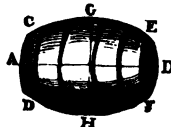
EXAMPLE.

(6.) Let the length, A D, of a cask be 40 inches; head diameter, $EF = CD$, 24; bung diameter, G H, 32; required its content?

Set the brass cock on the slider to 24 on the line of inches on the

end of the slider to the length of the cask on the upper line of the rule ; look for the mean diameter on the upper line

stock, and immediately over 32 on the middle or spheroid line of the slider is 5·6. Find 5·6 on the line just below the spheroid line on the slider, and it will be found to cut 29·6 on the inch line of the stock ; 5·6 is thus added to the head diameter, and makes 29·6 for a mean diameter, to be used as the diameter of a cylinder. Then set the brass end of the slider, which is the gauge point for gallons (18·79), to 40, the length, on the upper part of the stock, C, and opposite 29·6, the mean diameter, on the upper line of the slider, D, will be found 99·27 on the stock, C, the content in gallons. Or, in other words, 18·79 on D : 40 on C :: 29·6 on D : 99·27 on C.



Should any of the dimensions be thrown off the rule, use half the dimensions thrown off, and double the answer.

The other modes in which the content of a spheroidal cask can be measured, namely, by the pen, the Sliding Rule, Table of Circular Areas, Tables of Factors for head and bung diameters, or Table of Circumferences,—are inserted under the head *Spheroids*, &c. in p. 128.

If it should be desired to calculate the content of a cask, as of any other variety than a spheroid, the rules for that purpose will be found under the proper heads, namely,

2nd Variety, middle frustum of a parabolic spindle, p. 132.

3rd Variety, lower frustum of two parabolic conoids, p. 130.

4th Variety, lower frustum of two equal cones, p. 113.

To find the content, according to *Hutton's Variety*, add into one sum 39 times the square of the bung diameter, 25 times the square of the head diameter, and 26 times the product of the two diameters ; multiply the total by the length and by ·000031473. Thus in the foregoing example : $[(32^2 \times 39) + (24^2 \times 25) + (32 \times 24 \times 26)] \times 40 \times \cdot 000031473 = 93\cdot 54$ gallons. This by the pen is very laborious, and seldom acted upon ; but the formula by the Sliding Rule is much more simple, and in *Needle's Gauging* is represented as remarkably easy and expeditious. The head diameter is divided by the bung, and opposite to the quotient in a Table is a gauge point, which being used on the lines C and D, gives the content at one operation ; for instance, in the above example, $24 \div 32 = \cdot 75$, the gauge point opposite to which in the Table is 20·92 : then, 20·92 on D : 40 on C :: 32 on D : 93·5 gals. on C. These gauge points are found by adding to 39, 25 times the square of the quotient of the head divided by the bung, and 26 times the same quotient, and multiplying the sum by ·000031473 ; the product is a factor, the square root of the reciprocal or divisor of which is the gauge point in question. The formula is expressed as follows, where C is the content and x the factor : $C = B^2 L x$, x being found from $H \div B$: thus, $x = [39 + 25 (H \div B)^2 + 26 (H \div B)] \times \cdot 000031473$. See *Hutton's Mensuration*, Edition 1788, p. 593. The idea of these gauge points is said to have been suggested by Mr. John Lowry, of the Military College, Sandhurst, formerly an officer of Excise. (See *Keith's Mensuration*, p. 277.) Mr. Woolgar's rule for finding the content of this variety is given in p. 70, and, as applied to the above cask, is as follows :—24 on A : 32 on B :: 1 on B : 20·93 on X, the gauge point. Then 20·93 on D : 40 on C :: 32 on D : 93·5 on C, gallons, the content. This is probably the easiest mode of computing the content of casks which has been discovered, except Dr. Young's method, which does not appear to have been completed. It has the advantage of Dr. Hutton's, in being expressed on the rule itself, so

of the slider, and over it, on the upper line of the rule, is the content in gallons.

as to be used without reference to a table; and when it is not on the rule, the gauge points can be easily found from the diagram in p. 70.

To find the content of a cask, according to *Dr. Young's* variety, he suggested a very simple mode of operation, an explanation of which appeared in the *Mechanics Magazine*, No. 182. Instead of the formula being as in the old method, $C = L M^2 \div 353.036$, it was $C = L B^{1.5533} H^{0.6467} \div 353.036$ (1.5533 and 0.6467 together being equal to 2); which, although it does not admit of arithmetical application without the aid of logarithms, yet is extremely suitable to the principle of the Sliding Rule, on which new lines were to be graduated, so that when the head was set opposite to the bung, the content in gallons would be found opposite to the length, at a single operation. But Dr. Young unfortunately fell into an error which has been common with almost all scientific men who have not been practical gaugers. He speculated about the *forms* of different casks, instead of attending to the mode of *finding* the content of that form which was universally adopted. If he had applied his principle to the spheroidal form of casks, it would have left nothing further to be desired by practical men. As it was, I am not aware that his lines were ever brought into actual use. Their existence, indeed, was so little known, that a Mr. White, not long ago, introduced some lines of a similar description, of which he claimed to be the inventor. Mr. White's contrivance had, however, a novelty in its application: there were several diagonal pieces attached to the sliding part of the rule, and applicable to the different ranges of heads of casks. These diagonals were made to intersect graduations on the stock of the rule, applicable to the different ranges of *bungs* of casks; so that when the head was set against the bung, the line A showed the content opposite to the length on the line B at one operation.

The rule for finding the content of a cask, according to *Todd's Variety* (p. 153), is as follows:—To the square of the sum of the bung and head diameters add the square of twice their difference; then the aggregate being multiplied into the length, and by $\cdot 00070814$ (=one-fourth of the circular factor), will give the content; thus, in the foregoing example:—

$56 (=24+32)^2 + 16 (=32-24 \times 2)^2 = 3392$. And $3392 \times 40 \times \cdot 00070814 = 96.08$ gals.

By the Sliding Rule.

$37.58 (=18.79 \text{ IM G} \times 2)$ on D : 40 on C :: $\left\{ \begin{smallmatrix} 56 \\ 16 \end{smallmatrix} \right\}$ on D : $\left\{ \begin{smallmatrix} 88.83 \\ 7.25 \end{smallmatrix} \right\}$ on C 96.08 cont

The rule for finding the content, according to *Kentish's Variety* (p. 153), is to add the square of the head to twice the square of the bung, and multiply the sum by the length and by $\cdot 000919$ (=the factor of 33^3); thus, in the foregoing example:—

$24^2 + 2(32^2) = 2624$. And $2624 \times 40 \times \cdot 000919 = 96.46$ gallons content.

By the Sliding Rule.

33 on D : 40 on C :: $\left\{ \begin{smallmatrix} 24 \\ 32 \end{smallmatrix} \right\}$ on D : $\left\{ \begin{smallmatrix} 21.1 \\ 37.7 \\ 37.7 \end{smallmatrix} \right\}$ on C 96.5 content.

Kentish does not state what proportions of the spheroidal and conical frustums will produce his factor and gauge point; but he specially recommends the use of the latter, in consequence of its being a whole number, and of easy application upon the Sliding Rule. The factor is also convenient for numerical calculation.

*To ullage a lying cask.**—Place the bung diameter on the lower line of the slider (B) to 100 on the lower line of the

Todd states that of 47 casks, 35 were nearer the truth, calculated by his general rule, than by Dr. Hutton's, the remaining 12 agreeing better with Dr. Hutton's rule. Kentish states that in 47 out of 50 casks measured, his rule came nearer to the truth, and in 3 only Dr. Hutton's came nearer to it. The following table shows at one view the content of a cask according to the different varieties, the dimensions remaining the same as in the foregoing example, namely, L 40, B 32, and H 24, proving the impracticability of accurately measuring all casks by one general rule, without reducing them by allowances or deductions to a particular standard or variety.

Variety.		gallons.
1st,	(p. 128.) $2(32^2) + 24^2 \times 40 \times \cdot 0009442$	99·103
2nd,	(p. 132.) $[2(32^2) + 24^2] - 25\cdot6 [(32 - 24 = 8 \times 2)^2 \div 10]$ $\times 40 \times \cdot 0009442$	98·136
3rd,	(p. 130.) $32^2 + 24^2 \times 40 \times \cdot 0014163$	90·64
4th,	(p. 113.) $[32^2 + 24^2 + 56^2 (= 32 + 24)^2] \times 40 \div 6 \times \cdot 002632$	89·41
Hutton's	(p. 162.) $[(32^2 \times 39) + (24^2 \times 25) + (32 \times 24 \times 26)] \times 40 \times$ $\cdot 000831473$	93·54
Young's	(p. 69.) $1\cdot4 + (\cdot 5625 \times \cdot 6) + \cdot 75 = 2\cdot4875 \times 38\cdot66624$	96·18
Todd's	(p. 163.) $(32 + 24)^2 + 16^2 (= 32 - 24 = 8 \times 2)^2 \times 40 \times$ $\cdot 00070814$	96·08
Kentish's	(p. 163.) $[2(32^2) + 24^2] \times 40 \times \cdot 000919$	96·46

For other modes of calculating the different varieties, see the pages referred to.

If a middle diameter between the bung and head has been obtained, which is the correct mode of cask gauging, the content may be found, as in p. 157. If the middle diameter of the cask in the above example had been 30·2 the content would be 99·104, being the same as the first variety (p. 128), but the content, of course, would vary with the middle diameter.

Another mode of finding the quantity of spirits contained in a cask, and which it is understood is practised to some extent by the trade, is by *weight*, as follows:—Weigh the cask, and deduct the tare, if known, and if not, empty the spirits into a vessel whose tare is known, and then weigh it; or weigh the cask when empty and deduct the tare. Ascertain the indication on the hydrometer, and the specific gravity from Table No. 19, and divide the weight in pounds by the specific gravity, and the quotient by 10 (the number of pounds in a gallon); the last quotient is the content in gallons.

Thus, taking the foregoing cask and supposing it filled with spirits at the hydrometrical indication of 40·8, and weighing 7 cwt. 3 qrs. 10 lbs., after deducting the tare of the cask; what is its content?

878 lbs. (= 7 cwt. 3 qrs. 10 lbs.) $\div \cdot 8869$ (tab. sp. grav. of the spirits) $\div 10$ = 99 gals. Ans. (See pp. 43, 208.)

In *Long's Tables*, the contents are given with the weights and specific gravities. The specific gravities of spirits of different indications on Sike's hydrometer, are shown in Table 19, in the Appendix.

The contents of the casks in Table No. 49, having been calculated by the head rod, may be considered as examples under this rule, and selections from it made for practice.

* When a cask is only partly filled it is said to be on *ullage*, the vacancy or space being called the *dry inches*, and the depth of liquor or materials the *wet inches*. The usual mode of casting such ullage is by the head rod (as in the text), or sliding rule (see p. 71); and although in most cases these instruments give only an approximation to the truth, yet this is generally near

rule (seg. ly.); find the wet inches to the left of the bung on the same line (B), under which, on the lower line of the rule (seg. ly.) is a segment to be reserved. Find the seg-

enough for practical purposes, especially when the casks are nearly full, as is mostly the case with those on which the duty has to be charged. At the ports, the ullages are always calculated on the casks when lying, there being no segment for standing casks marked on the head rod.

EXAMPLE OF A LYING CASK.

(7.) Find the wet ullage of a lying cask of the following dimensions :—

Bung 32, wet 26·5, content 99·27.

32 on C : 100 on Seg. L. :: 26·5 on C : 90·8 on Seg. L.

Then 90·8 on B : 100 on A :: 99·27 on A : 90·1 on B. ull.

Or 100 on B : 90·8 on A :: 99·27 on B : 90·1 on A. ull.

Or, instead of the latter operation, multiply the content by the segment, and the product, after pointing off two decimals more than in common multiplication, will be the required ullage; thus :—

$$99·27 \times 90·8 = 90·13.$$

The operation is the same by the sliding rule, in which the line Seg. Ly. or S. L. is always marked. See the note and example in p. 72.

The dry ullage will be obtained in the same manner, the dry inches being used instead of the wet. Therefore should the number of wet inches fall off the rule, find the dry ullage, and subtract it from the wet inches.

To find the ullage by numerical calculation is a tedious process; but for ordinary purposes, the following rule will answer :—Divide the wet inches by the bung to three places of decimals; and if the quotient exceed ·500, add to such quotient one-fourth of the excess; but if it be less than ·500 subtract one-fourth of the deficiency; then multiply the whole content of the cask by the sum in the first case, or by the remainder in the second, the product will be the ullage. Thus, in the foregoing example, $26·5 \div 32 = ·828$, which exceeds ·500 by ·328, one-fourth of which is ·082. Then, $·828 + ·082 = ·910$. And $99·27 \times ·910 = 90·3$ ullage.

This rule is the one in common use by the Excise Officers, although it is somewhat less correct in many cases than the ullage lines on the Sliding Rule. The following rule is sometimes substituted :—From 5 times the product of the content and wet inches, subtract the product of the content multiplied by half the bung; the remainder divided by 4 times the bung will give the wet ullage. The dry inches, will give the vacuity. Thus, in the foregoing example, $99·27 \times 26·5 \times 5 = 13153·275$; and $99·27 \times 16 (=32 \div 2) = 1588·32$. Then, $13153·275 - 1588·32 \div 128 (=32 \times 4) = 90·3$ ullage.

The same result will be obtained if we subtract the bung from 10 times the wet inches, multiply the remainder by the content, and divide by 8 times the bung.

(8.) If the foregoing cask contain 90·3 gallons spirits, at 30 per cent. over proof, what is the quantity to be charged with duty at proof?

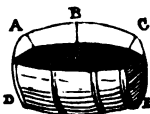
$$100 : 90·3 :: 130 : 117·39 \text{ gals. Ans.}$$

By the Sliding Rule.

$$100 \text{ on A : } 90·3 \text{ on B :: } 130 \text{ on A : } 117·4 \text{ on B. Ans.}$$

See further examples in pp. 44, 59, 105.

To find the wet or dry inches when any certain quantity has been drawn out of a lying cask.—Add the product of the content, multiplied by half the bung, to 4 times the product of the quantity drawn and bung; divide the sum by 5 times the content, which gives the dry inches; the quantity in the cask will give the wet inches.



ment on the slider (B), which place to 100 on A; look for the full content of the cask on A, and directly under, on the slider (B), will be the ullage content or quantity of liquor in the cask.

*To ullage a standing cask.**—Proceed in the same manner as for a lying cask, using the line marked (seg. st.), instead of

* EXAMPLE OF A STANDING CASK.

(9.) Find the wet ullage of a standing cask of the following dimensions:—Wet 26·5, length 40, content 99·27.

40 on B : 100 on seg. st. :: 26·5 on B : 67·5 on seg. st.

67·5 on B : 100 on A :: 99·27 on A : 67 on B, ullage.

Or, 100 on B : 67·5 on A :: 99·27 on B : 67 on A.

Or the latter operation may be performed by multiplication, as for a lying cask (p. 165). See also the note and example in p. 72.



To find the ullage by numerical calculation.—Divide the wet inches by the length of the cask to three places of decimals, and if the quotient exceed ·500, add to such quotient $\frac{1}{10}$ of the excess; but if it be less than ·500, subtract $\frac{1}{10}$ of the deficiency; then multiply the whole content of the cask by the sum in the first case, or by the remainder in the second; the product will be the ullage. Thus, in the foregoing example, $26·5 \div 40 = ·6625$, which being more than ·500 by ·1625; add $\frac{1}{10}$ of the excess, viz. ·01625, $=·67875 \times 99·27 = 67·38$ ullage.

Another rule is as follows:—From 11 times the product of the content and wet inches subtract the product of the content multiplied by half the length; the remainder, divided by 10 times the length, gives the wet ullage. The dry inches will give the vacuity. Thus, in the foregoing example, $99·27 \times 26·5 \times 11 = 28937·205$, and $99·27 \times 20 (= 40 \div 2) = 1985·4$. Then, $28937·205 - 1985·4 = 26951·805 \div 400 (= 40 \times 10) = 67·37$ gals. ullage.

If the cask be open, and the diameter can be obtained on the surface of the liquor, the ullage may be found by the general rule for frustums (p. 114); or if equidistant diameters can be obtained, the ullage may be found by the modification of the same rule in p. 150, as in the following example:—

The depth of liquor in a cask, partly filled, is 20 inches; five equidistant diameters, measured from the surface of the liquor downwards, are 28, 27, 26, 24, and 22 inches; required the content?

Extremes	{	28	tab. area		3·2207
		22			1·3709
Evens	{	27	..	2·0649	
		24	..	1·6315	
				<u>3·6964</u>	$\times 4$. . 14·7856
Odd	. . .	26	. . .	$1·9148 \times 2$	 3·8296
					<u>22·2068</u>
				Multiply by 5, com. distance	 5
					<u>3) 111·0340</u>

37·0113 content.

To find the wet or dry inches in a standing cask when any certain quantity has been drawn out.—To 10 times the product of the quantity drawn and the length of the cask, add the product of the content multiplied by half the

that marked (seg. ly.), and taking the length instead of the bung diameter.

XV. MALT FLOORS.*

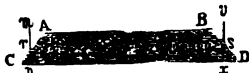
Malt Floors are usually in the form of rectangular solids ; and when they are so, they are gauged according to the directions in the preceding sections. When a floor varies a little from a regular figure, a mean is taken, or an allowance

length ; that sum divided by 11 times the content gives the dry inches. The quantity in the cask gives the wet inches.

To inch and tenth a cask to correspond with the ullage rule.—First find the ullage of the cask at two or three inches from the bottom, and divide the content of the ullage by the depth, reduced into tenths to two or three places of decimals. This will give a common addend for that depth ; and by proceeding to ullage the cask at any number of even inches, a common addend will be obtained for each portion of the cask, from which a table-book may be formed. If the cask be the frustum of a cone, it may be inched by means of top and bottom diameters of the different sections, for finding which directions are given in p. 112. But a more certain mode of inching a cask is by pouring in water from a known measure, and taking the dip from time to time, either in putting in or drawing out the water. From the contents found on the respective dips a table may be formed. If the cask be well made, it may be sufficient to fill it to half the depth, and calculate the corresponding sections of the other half according to the dips found in the lower half.

* The proper and usual mode of gauging malt floors is shown in p. 100. Maltsters are, in fact, required by law to place their floors in rectangular forms, for the purpose of being gauged. Should it, however, be necessary to measure a piece of malt in the form of a cone, pyramidal frustum, or wedge, directions for doing so will be found in pp. 108, 115, 119 ; and irregular malt floors may be measured as in the following examples :—

(1.) Let A B C D be the end of a piece of malt with slanting sides to be measured. Half-way between A and C let a rule, as $m n$, be set up perpendicularly, and another, $v x$, perpendicularly, half-way between B and D. Then extend a tape from r to s , or from m to v , parallel to $r s$, regarding $r s$ as the breadth of the floor. In like manner, the length must be taken if the ends be slanting. The depth is obtained by taking the average of ten or more dips in the usual manner, and the content calculated as in p. 100.



(2.) If both ends and sides of a floor of malt be slanted, as in the figure in the margin, the tape may be fixed at the innermost sloping edge of one end, as D, by putting the dipping piece through the ring ; and then extended to the outermost sloping edge of the opposite end of the floor, B A, which may be found by dropping a few grains of corn. You will thus have one length of the floor, for what is lost at one end, will be gained at the other. In the same manner, find several



made, to bring it as nearly as possible into a regular form. If there be any greater irregularity in the form of the floor, it must be divided into parallelopipedons or other regular forms, and the content of each part found separately, and added together for the whole content.

other lengths, taking care to fix the end of the tape alternately at the opposite ends of the floor, so as to obtain a mean, if one end slant more than the other.

(3.) If one end or one side slope and the other be laid against an upright wall, as represented by the figure in the margin; fix the end of the tape close to the wall, and extend it in a horizontal direction from r to s , r being half-way between M and O , and proceed in other respects as in the former example. (See p. 101, &c.)



CHAPTER V.

BOOK-KEEPING.

BOOK-KEEPING* is the method of keeping accounts in such a manner that a person may know at any time the true state of his affairs.

Book-keeping by *Single Entry* requires two principal kinds of books, a Day-Book and Ledger. The Day-Book begins with a list of debts due to and from the owner ; then

* By recent regulations of the Treasury, the accounts of the Revenue are to be kept upon the system of Book-keeping by Double Entry, and all Revenue Officers are required to have a knowledge of this system. It is, in fact, now always made a subject of examination before a person can either be admitted into or promoted in the Excise Establishment. It is therefore proposed in the present Chapter to give a brief outline of the system, with a few practical illustrations, to enable the Officer to qualify himself for the examination referred to.

The books kept by an Officer of Excise in the ordinary discharge of his duty differ materially from those kept in a merchant's office. The principal book in which the Officer enters his Surveys, and which is called, on that account, the "Survey Book," contains an account of what he sees and does when he makes his periodical visits to the premises under his survey ; and the chief object of these entries is, as already stated, to raise a *charge* against the trader, which, when his process is completed, will show the amount of duty payable to the Crown. These and the other books used by the Officer for completing his charges are supplied by the Commissioners in blank ; and they are required to be kept according to certain forms and precedents furnished to the Officers in the "Instructions" issued for their guidance.

The Books in which the Officers' charges are afterwards entered by the Collectors and Accountants approximate more nearly to those kept in a merchant's office, and it may be interesting to know in what manner the Double Entry System is applied to them. This is shown in the following note, which has been furnished by J. S. LYNK, Esq., Accountant-General of Inland Revenue.

"In the Books kept in the Excise department, the Waste Book of the mercantile system is subdivided into the 'Trader's Ledger,' and various 'Cash Receipt' and 'Cash Payment' books. In the former the charge of each round or other period is carried to the debit of the respective traders, and as

every transaction by which new debts are contracted, or former debts discharged, is entered as it occurs; with the quantities, price of goods bought or sold, or other circumstances necessary for explaining the transaction. These transactions are subsequently posted into the Ledger, which contains an account for every person with whom there are

these are paid off, the trader's account is credited and the amount flows to the debit of cash. In the Cash-books all the transactions of receipt and payment are entered daily under proper heads provided in them. These books are aggregated daily, and the total of each carried to a "General Cash Book" having a Dr. and Cr. side, and containing a line for each head of Receipt and Expenditure. The receipts being carried to the Dr. and the payments to the Cr. side, and being cast up at the end of the day, the Balance will be the sum in the collector's hands, and he has thus the means of testing the accuracy of the account.

"The contents of the 'General Cash Book' are carried to their respective heads of account in the 'Abstract of Duties Charged, &c.,' which is so framed as to arrange and aggregate the transactions of the round, under the proper heads of account. As it would be obviously impracticable to post each day's transactions into the Ledger, from the subsidiary books, the 'Abstract' is provided as an intermediate stage in which to collect all the transactions of the round, and is formed on the principle of double entry. These Abstract Books are particularly and especially adapted to official accounts, which being for the most part of a uniform character, the nature of the transactions can be foreseen, and admit of the use of printed forms. These books have, therefore, been provided with columns, headed to provide for all the ordinary transactions of the Revenue, corresponding with accounts opened in the principal Ledger. In addition to columns for every transaction, a line is also provided for each day of the round, so that no difficulty may be experienced in transcribing from the 'Subsidiary' books and documents into the Abstract. At the end of the Round the Abstract should be totalled and the amount of the Dr. entries will balance that of the Cr. entries, if they have been correctly posted, in the same manner as in a Journal constructed on the principle of double entry. At the chief office the Abstract takes up the accounts of the Receiver General, as well as those of the collectors, all of which are brought into one grand total every round. It is thought necessary also at the chief office, where the whole accounts of the country and London are brought to a focus, that, for the purpose of accuracy in accounts of such number and magnitude, a double-entry 'Journal,' in addition to the 'Abstract' before described, should be kept. As this book relates to the chief office only, and not to the officers generally, and as the detail of its purposes and description would occupy much space, it will not be necessary to explain more than its principle; because upon that principle the double-entry system, as applied to the Excise Revenue, is founded. In order to understand, however, the explanation of the Journal, it is needful to bear in mind that in the 'Principal Ledger' an account is opened for each article of Duty, that is for 'Malt,' 'Paper,' 'Spirits,' &c., &c.; for each item of expenditure, as 'Salaries,' 'Superannuation allowances,' 'Drawbacks on Beer,' on 'Soap,' &c. &c.; for 'Remittances,' 'Cash,' 'Arrears,' and 'Excise Revenue.' The double entry is thus applied to Excise transactions: the several duties are made Drs. to Excise Revenue *for* the charge, and consequently the Journal entry is thus made:—'Sundries Drs. to Excise Revenue,' which causes the charge to be passed to the debit of each Duty,

dealings on credit ; the articles for which he is accountable to the owner, and those for which the owner is accountable to him, being placed in opposite pages of the same folio ; the Dr. articles on the left hand-pages, and the Cr. on the right hand pages.

Book-keeping by *Double Entry* requires three principal books, namely, a Waste Book, a Journal and a Ledger ; in the first of which, the current transactions are entered in the same way as in the Day-Book by single entry ; in the second, each transaction recorded in the Waste Book is

and the total charge to the credit of Excise Revenue ; such debits and credits constituting a double entry. The account 'Consolidated Duties' has been generally used as an intermediate account between the several duties and Excise Revenue ; but it is better to discontinue the first-mentioned account, and to carry the charge to 'Excise Revenue' at once, by making the several Duty Accounts Drs. to 'Excise Revenue' for the charge, instead of to 'Consolidated Duties.'

"The amount of the several duties received is thus treated : 'Cash Dr. to Sundries,' thereby debiting Cash and crediting the several duties with the sums collected. In the case of payments, the double entry is thus managed : say for salaries, superannuations, &c., 'Sundries Dr. to Cash,' by which means the heads of account opened for salaries, superannuation allowances, &c., are debited with the sum paid for them respectively, and Cash is credited ; or 'Drawback on Beer Dr. to Cash,' 'Remittances Dr. to Cash,' &c. &c., as the case may be. These details will be sufficient to explain the design and principle of the Journal, and its relation to the 'Principal Ledger.'

"In the 'Principal Ledger,' accounts are opened, as before stated, for each item of charge, and for each item of expenditure, as well as for Cash, Excise Revenue, &c. To these heads of account the several transactions are posted from the 'Abstract' by the Collectors, and from the 'Journal' at the chief office. In posting into the Collector's 'Principal Ledger,' no difficulty can be experienced by a person at all acquainted with Excise transactions, the heads of account being all provided and printed in that, as well as in all the other books directed to be used by the Collectors. The 'Principal Ledger' in use at the Chief Office is kept on the same principle as that used by Collectors ; but, of course, more accounts are required to be opened in it, inasmuch as all the transactions of the Receiver General are passed therein to the respective accounts provided for the purpose ; and in addition to the Heads of Account opened for the Charge, and Receipts and Payments, a personal account is opened with each Collector. When all the year's transactions have been carried through the several books to their respective accounts in the Ledger, it becomes necessary to close them, and to make up what is called a 'Balance Sheet.' The accounts of the *Principal Ledger* are balanced by the account 'Excise Revenue,' which account may be said to embrace at once the 'Stock Account,' the 'Profit and Loss Account,' and the 'Balance Account,' of the mercantile Ledger.

"The charge, as before stated, having been passed as it accrues to the debit of the several duties, and the credit for the account of 'Excise Revenue,' and the Expenditure Accounts and the Account of Remittances being closed by the same, the two sides of the account should be added up, and the dif-

arranged under its proper title of Dr. and Cr. ; and in the third, the respective parties or articles entered in the Journal, are debited and credited in their respective accounts ; the result being that by this system, as its name imports, every transaction is doubly entered ; every debtor having a creditor, and every creditor a debtor. In many cases subsidiary or auxiliary books are kept according to the nature of the business carried on, but the three principal ones already named will be sufficient to illustrate the system for the present purpose.

I. WASTE BOOK.

The Waste Book * commences with an inventory of the sum of money a merchant employs in business, the different quantities of merchandise in his possession, and the debts

ference or balance will be, if correct, equivalent to the amount of the *uncollected duties, arrears, cash in the Collector's hands, and any other transferable accounts*, at the close of the year. The Balance-Sheet is a transcript of the 'Excise Revenue' Account, only reversing the Dr. and Cr. sides ; the Collector obviously standing in the opposite position to the Revenue in matters of account, that is, where the collector would be debtor, the Revenue would be creditor, and *vice versa*. At the foot of the Balance Sheet it is proper to set forth the particulars of the balance transferred, which are properly called the assets of the department, and therefore should be stated on the credit side. The process of balancing the accounts at the Chief Office is necessarily more elaborate than with the Collectors, because, in the 'Principal Ledger' there kept, personal, as well as real, accounts are opened. The principle, however, is the same, and the accounts are all closed and balanced to or by 'Excise Revenue,' which account forms the basis of the Balance Sheet."

* The Waste Book is the book in which the daily transactions are first entered ; but for the convenience of business it is generally subdivided into a variety of what are called "Subsidiary Books," such as a Stock Book, Bills Receivable Book, Bills Payable Book, Cash Book, Sales Book, Warehouse Book, &c., the whole of which are aggregated weekly, monthly, or quarterly, as the merchant or trader may think proper, and are then passed into the Journal. The use of these subsidiary books being apparent from their titles, it will not be necessary to enter into farther details respecting them. A brief account of the three principal books will be sufficient to enable the Officer to understand the principles on which the system by Double Entry is founded.

The Waste Book, if no subsidiary books are kept, should contain a record of all the merchant's transactions, including every occurrence that affects his stock, so as to impair or increase it,—such as private expenses, money gained, &c. The dates may either be inserted in the margin or at the head of each transaction, as in the Journal. Each transaction should be entered as soon as

due to and by him, and after this, a distinct record is made of all his dealings, in the order of time as they succeed each

it takes place, and should be expressed in the plainest language, and with as much brevity as possible, consistent with perspicuity. The subjoined form is supposed to be an extract from a merchant's Waste Book, including the first entries and a few daily transactions, which are selected so as to give as much diversity as possible. The transactions are limited to a single one each day, in order that the dates may serve as references to the corresponding entries in the Journal. An extract of this description is usually placed in the hands of an Officer when it is intended to test his knowledge of Book-keeping, and he is required to frame a set of books from it, which, it is presumed, he will be able to do by attending to the following directions.

WASTE BOOK.

LONDON, JANUARY, 1852.			
Date.		£	s. d.
1	Inventory of the effects of John Williamson:—		
	Cash on hand	568	0 0
	Alum . . . 14 cwt. at 12s. 6d. per cwt.	8 15 0	
	Copperas 17 cwt. at 5s. per cwt.	4 5 0	
	Tobacco . 9 cwt. at 3s. per lb.	151 4 0	
	Wine . . 2 pipes Port, at £72	144 0 0	
	" . . . 5 hhds. Sherry, at £40	200 0 0	
	" . . . 1 do. do. in bond	20 0 0	
	Debts due to me:—	528	4 0
	Thomas Gray	132	2 6
	James Wilson	150	0 0
	Bills Receivable:—		
	Joseph Mason's Acceptance, due 8th Jan. 1852	150	0 0
		1523	6 6
	Debts due by me:—		
	Johnson & Co.	50	0 0
	John Smith	20	0 0
	Murray & Co.	35	0 0
	Bills Payable:—		
	James Reid, my Acceptance, due 10th Jan.	75	0 0
		180	0 0
2	Paid Johnson & Co. in full	50	0 0
3	Sold to John Smith 6 cwt. Copperas, at 7s. per cwt.	2	2 0
5	Received from Thomas Gray in part of old account	50	0 0
6	Bought of Murray & Co. 1 pipe of Port Wine	80	0 0
7	Bought for ready money 18 cwt. Alum, at 12s. per cwt.	7	16 0
8	Sold for cash 5 cwt. Tobacco, at 3s. per lb.	84	0 0
9	Received for Joseph Mason's acceptance, due this day	150	0 0
10	Paid James Reid for my acceptance, due this day	75	0 0
12	Sold Thomas Meekins 4 cwt. of Tobacco, at 4s. 3d. per lb., and received his bill at 3 months	95	4 0

other. As a general rule, each entry ought to contain the following particulars, namely, the date; the nature of the transaction, as buying, selling, &c.; the person dealt with; the quantity, quality, and price of the article; and the mode of payment.

Date.	JANUARY 1852.			
		£	s.	d.
13	Bought of Messrs. Williams & Co. 3 hhd. Sherry, at £40 per hhd., and gave my bill at 3 months	120	0	0
14	Paid Customs duty, warehouse rent, and Dock charges on 1 hhd. of Sherry	34	15	6
15	1 hhd. Sherry in stock burst, and the wine lost	40	0	0
16	Received a gift from my father	50	0	0
17	Henry Adams & Co. paid into the Westminster Bank on my account	100	0	0
19	Sold for cash:— 11 cwt. Copperas, at 6s. 8d. per cwt. . . 3 13 4 4 cwt. Alum, at 15s. per cwt. 3 0 0 2 pipes of Port Wine, at £75 per pipe 150 0 0	156	13	4
20	Bought of Thos. Harding 10 cwt. Tobacco, at 3s. 6d. per lb. Paid him in part 60 0 0 Leaving unpaid 136 0 0	196	0	0
21	James Wilson being insolvent, I have accepted a composition of the debt due by him to me, and discharged the same. Composition received on £150, at 15s per £ 112 10 0 Balance lost 37 10 0	150	0	0

The following form shows the mode in which the transactions included in the foregoing specimen Waste Book are recorded in the Journal, the occurrences being limited to one for each day, in order that the day of the month may serve as a reference from one book to the other, such dates being also used for reference in the following notes. It is the practice in modern accounts to use double columns in the Journal, the debits being entered in the first, and the credits in the second; and these, being added up, should always balance, and show at any time the extent of the merchant's transactions during the period embraced in the details aggregated. The sum of these columns should also correspond with the "Trial Balance" of the Ledger (p. 180).

The transactions are transferred from the Waste Book to the Journal in the same order as that in which they are entered, commencing with the inventory of the effects. This inventory is entered in the Journal under the head of "Sundries Dr. to Stock," the different items constituting the sundries being expressed under the heads of Cash, and other articles, in respect of which it is intended to open accounts. The debits and liabilities are entered as "Stock

II. JOURNAL.

The Journal is the most important book in the series, as in it the various transactions recorded in the Waste Book and subsidiary books are assorted under the heads of debtor and creditor, preparatory to their being posted to the various ledger accounts in the Ledger. This book, like the Waste

Dr. to Sundries," the respective creditors and liabilities being particularised in the items.

In making Journal entries of the different transactions, it is first to be considered what is to be entered as Dr., and what as Cr., the general rule being that everything received is Dr., and everything delivered, Cr. If nothing is received, the person accountable to us is Dr.; and if nothing is delivered, the person to whom we are accountable is Cr. This will be better understood by the following illustrations :—

I. *The person to whom anything is delivered is Dr. to the thing delivered when nothing is received in return*; therefore, when money is paid and nothing is received, as in (2), the receiver is Dr. to Cash; and when goods or other property are sold on credit (which must always be presumed unless "Cash" is mentioned), as in (3), the purchaser is Dr. to the thing sold.

II. *A thing received is Dr. to the person from whom it is received when nothing is delivered in return*; therefore, when money is received and nothing delivered, as in (5), Cash is Dr. to the payer; and when goods are bought and not paid for, as in (6), the goods are Dr. to the seller.

III. *A thing received is Dr. to the thing given for it*; therefore, goods bought for ready money, as in (7), are Dr. to Cash; and when goods are sold for ready money, as in (8), Cash is Dr. to the goods. When cash is received for a bill, as in (9), Cash is Dr. to Bills Receivable. When cash is paid for a bill, as in (10), Bills Payable are Dr. to Cash. When goods are sold and a bill is received in payment, as in (12), Bills Receivable are Dr. to the goods; and when goods are bought, and a bill given in payment, as in (13), the goods are Dr. to Bills Payable. If goods are bartered, the goods received are Dr. to the goods delivered.

IV. *Goods and other real accounts are Dr. for all charges laid out on them. If money be laid out, they are Dr. to Cash; if anything else be delivered, they are Dr. to the thing delivered; if the charge be taken in trust, they are Dr. to the person to whom it is due.* Therefore, when duties and expenses are paid on wine in bond, as in (14), the Wine is Dr. to Cash.

V. *When rents of houses or lands, freights of ships, bounties on goods, or any other profits from real accounts are received, Cash is Dr. to the account from which the profit arises; if anything beside money be received, the article received is Dr.; if they remain unpaid, the person who owes them is Dr.* Therefore, when freight is received, Cash is Dr. to the ship; and when rent becomes due, the tenant is Dr. to the property.

VI. *When an article of loss occurs, "Profit and Loss" is Dr. If the loss be paid in ready money, it is Dr. to Cash; if it be paid in anything else, it is Dr. to the thing delivered; if it remain unpaid, it is Dr. to the person to whom it is owing.* Therefore, when a gift is made in cash, Profit and Loss is Dr. to Cash; and when goods are taken for family use, Profit and Loss is Dr. to the goods; and so, if wine be destroyed, as in (15), Profit and Loss is Dr.

Book, usually commences, with an account of the effects and liabilities of the trader, and is opened by making the Sundry effects Dr. to Stock, and Stock Dr. to the several liabilities of the trader. In journalising the separate transactions, the debtor is always placed first; thus, Sundry accounts Dr. to Stock; Wine Dr. to Cash; or Bills Receivable Dr. to the

Wine; and if wages or interest become due, Profit and Loss is Dr. to the party to whom it is owing. Sometimes, however, warehouse rent, clerks' salaries, and petty disbursements are inserted under a separate account, as "Charges of Merchandise," in which case they are ultimately carried forward to Profit and Loss before completing the balance of the Ledger.

VII. *When an article of gain occurs that is not immediately connected with any real account, Cash, the article received, or the person accountable for it, is Dr. to Profit and Loss.* Therefore, a present or a gift received, as in (16), is Cash Dr. to Profit and Loss; and if the present be in goods, the goods are Dr. to Profit and Loss; and if interest, rent, &c. become due to us, the person indebted is made Dr. to Profit and Loss.

VIII. *When one person pays money, or delivers anything else to another on our account, the person who receives it is Dr. to the person who pays it.* Therefore, if a person pays money into a bank on our account, as in (17), the bank is Dr. to the person paying it in; and if a person delivers goods to another on our account, the person receiving is Dr. to the person delivering. Payments of this kind are often transacted by bills of exchange.

These examples will be sufficient to show the principle on which the Journal is made, and the rules extend to the greatest part of the simple transactions that occur in domestic trade. It may be observed that the technical sense of the words, Dr. and Cr., has an analogy to their meaning in common language, but is not precisely the same. Thus, in the example last referred to, (17) the Journal entry is, *Westminster Bank Dr. to H. Adams and Co.*, by which we are not to understand that the bank is indebted to Adams and Co.; for a debt between them has no connection with our business, and therefore ought not to be entered in our books: the meaning of the entry is, that the bank becomes indebted to us by the transaction narrated; and that we become indebted to Adams and Co. by the same.

When an entry has reference to various kinds of goods, as in (19), they are called "Sundries," the items being afterwards particularised, in order that they may be entered under their respective heads in the Ledger. The word "sundries," is also applied to accounts, when a transaction is of a mixed nature. Thus, if goods are bought partly for cash, and partly on credit, as in (20), the goods are made Dr. to Sundries, the Sundries being *Cash* for the amount paid, and the *Seller* for the amount unpaid. And so, if a composition be accepted from an insolvent and part of the debt lost, as in (21), Sundries are Dr. to the insolvent, the Sundries being "Cash" for the composition, and "Profit and Loss" for the balance.

If any difficulty be experienced in journalising these complex accounts, it may be removed by resolving them into simple ones. In particular, if there are both Drs. and Crs. in the same transaction, they must always be divided into two or more Journal posts, as the entry of "Sundries Dr. to Sundries" is not permitted.

After an article has been journalised, a dash or hook is made against it in the margin of the Waste Book, to show how far the accounts have been transferred into the Journal.

person giving the bill. Whatever is received in fact is made Dr. to the account of the article given in payment, or to the

JOURNAL.

LONDON, JANUARY 1, 1852.		Dr.			Cr.		
		£	s.	d.	£	s.	d.
1	Sundries, Dr. to Stock	...	...	...	1523	6	6
2	Cash	568	0	0			
3	Alum, 14 cwt., at 12s. 6d. . . .	8	15	0			
4	Copperas, 17 cwt., at 5s. . . .	4	5	0			
5	Tobacco, 9 cwt., at 8s. per lb. . .	151	4	0			
6	Wine, 2 pipes Port, at £72 £144						
	" 5 hhd. Sherry, at £40 200						
	" 1 do. in bond 20	364	0	0			
7	Thomas Gray	132	2	6			
8	James Wilson	150	0	0			
9	Bills Receivable, Mason's accep. due 8 Jan.	150	0	0			
1	Stock, Dr. to Sundries	180	0	0			
10	Johnson & Co.	...	...	...	50	0	0
11	John Smith	...	...	...	20	0	0
12	Murray & Co.	...	...	...	35	0	0
13	Bills Payable, my accep. to J. Reid, due 10 Jan.	...	...	...	75	0	0
	2						
10	Johnson & Co., Dr. to Cash . . .	50	0	0			
2	Paid them in full	...	...	...	50	0	0
	8						
11	John Smith, Dr. to Copperas . . .	2	2	0			
4	For 6 cwt., at 7s. per cwt. . . .	...	...	...	2	2	0
	5						
2	Cash, Dr. to Thomas Gray	50	0	0			
7	Received from him in part	...	...	...	50	0	0
	6						
6	Wine, Dr. to Murray & Co.	80	0	0			
12	For 1 pipe Port	...	...	...	80	0	0
	7						
8	Alum, Dr. to Cash	7	16	0			
2	For 13 cwt., at 12s. per cwt. . . .	...	...	...	7	16	0
	8						
2	Cash, Dr. to Tobacco	84	0	0			
5	For 5 cwt., at 3s. per lb.	...	...	...	84	0	0
	9						
2	Cash, Dr. to Bills Receivable . . .	150	0	0			
9	For Joseph Mason's bill, due this day	...	...	...	150	0	0

person from whom purchased, if bought upon credit; and consequently whatever is parted with in exchange, or the person giving the credit, will necessarily be Cr.

		Dr.			Cr.		
		£	s.	d.	£	s.	d.
— JANUARY 10 —							
18	Bills Payable, Dr. to Cash . . .	75	0	0			
2	For my acceptance to James Reid, due this day	...	...	...	75	0	0
12							
9	Bills Receivable, Dr. to Tobacco . .	95	4	0			
5	For 4 cwt., at 4s. 3d. per lb., sold T. Meekins, and received his bill at 3 months	...	...	...	95	4	0
13							
6	Wine, Dr. to Bills Payable	120	0	0			
13	For 8 hhds. Sherry, at £40 per hhd., bought from Williams & Co., and gave my bill at 3 months	...	...	...	120	0	0
14							
6	Wine, Dr. to Cash	34	15	6			
2	For customs duty, &c., on 1 hhd. Sherry	...	...	...	34	15	6
15							
14	Profit and Loss, Dr. to Wine . . .	40	0	0			
6	For 1 hhd. Sherry, which burst . .	...	...	...	40	0	0
16							
2	Cash, Dr. to Profit and Loss . . .	50	0	0			
14	For a gift received from my father	...	...	...	50	0	0
17							
15	Westminster Bank, Dr. to Henry Adams & Co.	100	0	0			
16	For amount paid by him to the Bank on my account	...	...	...	100	0	0
19							
2	Cash, Dr. to Sundries	156	13	4			
4	Copperas, 11 cwt., at 6s. 8d. per cwt.	...	...	...	8	13	4
8	Alum, 4 cwt., at 15s. per cwt. . .	...	...	...	8	0	0
6	Wine, 2 pipes Port, at £75 per pipe	...	...	...	150	0	0
20							
5	Tobacco, Dr. to Sundries	196	0	0			
2	Cash in part for 10 cwt. at 3s. 6d. per lb.	...	...	...	60	0	0
17	Thomas Harding, for the balance .	...	...	...	136	0	0
21							
8	Sundries, Dr. to James Wilson . .	...	...	...	150	0	0
2	Cash for Wilson's composition, at 15s. in the pound	112	10	0			
14	Profit and Loss for balance lost . .	37	10	0			

III. LEDGER.

The Ledger * is the book wherein all the transactions in trade are collected in their proper places under their proper

The total of the two columns of the Journal ought always to agree in amount : accordingly each of the foregoing columns, if totalled, will be found to amount to 3144l. 17s. 4d. On closing the Ledger for a final balance some bookkeepers journalise the Profit and Loss, and Balance Accounts. In this way, if the above accounts were to be closed on the 31st of January, immediately after the foregoing entries would be written "Sundries Dr. to Profit and Loss," with the last four items from the credit side of the Profit and Loss Account, amounting to 36l. 1s. 1d. This would be followed by "Profit and Loss Dr. to Sundries," with the last two items on the Dr. side of the same account, amounting to 46l. 1s. 1d. After this would be inserted, "Balance Dr. to Sundries," and "Sundries Dr. to Balance;" the former including all the items on the Dr. side of the Balance Account, amounting to 1840l. 15s. 7d.; and the latter all the items on the Cr. side of the same account, amounting to 488l. 18s. But this appears unnecessary when the details are given in the Ledger.

* The folios of the *Ledger* are divided into spaces for containing the accounts, on the head of which are written the titles of the accounts, marked Dr. on the left-hand page, and Cr. on the right: below which stand the articles with the word *To* prefixed on the Dr. side, and the word *By* on the Cr. side; and in the margin the dates are recorded in two small columns allotted for that purpose. The money columns are the same as in other books: before them stands the folio column, which contains figures referring to the folio where the corresponding Ledger entry of each article is made; for *everything is twice entered in the Ledger*, viz. on the Dr. side of one account, and again on the Cr. side of some other account; so that the folio figures mutually refer from the one to the other. Besides these columns, there must be kept in all accounts where number, measure, weight, or distinction of coins is considered, inner columns to insert the quantity. The Ledger is filled up from the Journal, as follows:—1, turn to the Index, and see whether the Dr. of the Journal post to be entered, be written there; if not, insert it under its proper letter, with the number of the folio to which it is to be carried. 2, Having distinguished the Dr. and Cr. sides, as already directed, record the date and complete the entry in one line, giving a short hint of the nature and terms of the transaction, with the name of its corresponding credit; carrying the sum to the money column and inserting the quantity, if any, in the inner column, and the referring figure in the folio column. 3, Turn next to the Cr. of the Journal post, and proceed in the same manner with it both in the Index and Ledger, making the entry on the Cr. instead of the Dr. side, and prefixing the word *By* instead of the word *To*. 4, The post being thus entered in the Ledger, return to the Journal, and on the margin mark the Ledger folios of the accounts with the folio of the Dr. above and that of the Cr. below, and a small line between them, thus: $\frac{3}{4}$; and where there are "Sundries" the folios of the respective items constituting the Sundries are to be inserted. 5, In opening the accounts in the Ledger, it is usual to follow the order of the Journal; that is, beginning with the first Journal post, allow the first space in the Ledger for the Dr. of it, the next for the Cr. of it, the third for the Dr. of the following post, if it be not the same with some of those already opened, and so on till the whole Journal be transferred; taking care

heads, the Waste Book and Journal being subservient to it. It contains the materials for the final arrangement of the

in every instance to allow as much space as the particular account is likely to require. In the following form, although the accounts are printed immediately beneath each other, to save room, each account is supposed to have an entire folio devoted to it, and it is numbered accordingly.

If the accounts are all thus properly brought forward from the Journal, and both sides of the several Ledger accounts added up and aggregated, the total amounts of the debits should correspond with the total amounts of the credits, and should also agree with the Dr. and Cr. columns in the Journal for the same period. It is usual to make these additions occasionally or periodically, being what is called a *Trial Balance*, and if it be found that the sides are not equal, it is certain that an error has crept in, which the book-keeper is thus enabled to detect. In the annexed form, if there had been a trial balance immediately after entering all the transactions recorded in the Waste Book and Journal, the total on each side would have been 3144*l.* 17*s.* 4*d.*

In this form also, the accounts are supposed to be closed for a General Balance on 31st Jan., and all the entries made with a view to such general balance are printed in italics. In this proceeding, we first begin with the "Cash" account, and having ascertained the difference between the totals, we insert it on the Cr. side as "Balance in Hand." At the same time we open an account for the "General Balance," which is intended as a substitute for the account which was formerly made separately, and called the "Balance Sheet," and in the Dr. side of this account, we insert the balance found in the Cash account. We then balance every account separately. This is done in all personal and imaginary accounts by finding the difference between the Dr. and Cr. sides. If they are equal, the account is closed; if not, we enter the

LEDGER.

(1)		STOCK.		Dr.	fo.	£	s.	d.
1852	Jan.	1	To Sundries	—	180	0	0	
			To Balance for net capital	18	1851	17	7	
					1581	17	7	
(2)		CASH.		Dr.				
1852	Jan.	1	To Stock	7	563	0	0	
		5	To Thomas Gray	7	50	0	0	
		8	To Tobacco	5	84	0	0	
		9	To Bills receivable	9	150	0	0	
		16	To Profit and Loss	14	50	0	0	
		19	To Sundries	—	156	13	4	
		21	To James Wilson	8	112	10	0	
					1166	8	4	
(3)		ALUM.		Dr.				
1852	Jan.	1	To Stock, 14 cwt., at 12 <i>s.</i> 6 <i>d.</i>	1	8	15	0	
		7	To Cash, 13 cwt., at 12 <i>s.</i>	2	7	16	0	
		31	To Profit and Loss gained	14	0	10	9	
				27	17	1	9	

merchant's affairs, including a faithful record of debts, with the "profits and losses" from particular articles, or from

difference, with the words "To" or "By balance," as the case may be, on the side of the account which requires it to make the totals equal; and carry such balance to the opposite side of the "Balance" account. In "Real Accounts," we ascertain whether the goods are disposed of; if they be, the difference of the amount between the two sides is entered on the proper side of the account as "Profit and Loss." If any remain, their cost price or estimated value is entered on the Cr. side of the account as "Balance," and if there be then any difference between the two sides, it is entered as "Profit and Loss." And the "Balance," or "Profit and Loss," or both, must, in any case, be carried forward to the proper side of the "Balance," or "Profit and Loss" account. The "Profit and Loss" account must then be balanced. If the larger sum appear on the Debit side there will have been a loss, and the balance is carried to the debit of the "Stock" account; but should the larger sum appear on the Cr. side, there will have been a profit, and the balance is carried to the Cr. side of the "Stock" account. That account must then be balanced by subtracting the Dr. from the Cr., and inserting the difference on the Dr. side as the "Balance of the Stock in Trade," at the time the accounts are made up. This last balance, if the accounts are correct, will be exactly the same as the final balance of the "Balance" account; and the several items of the "Balance" account will form the inventory for a new set of Books.

If it be thought advisable to check the final Ledger account with the Journal, it will be necessary either to take an inventory of the stock on hand, and add the items to those already in the Journal, or otherwise, to add to such items the items composing the Profit and Loss, and Balance accounts in the Ledger under their respective heads.

LEDGER.

		CONTRA.	Cr.	fo.	£	s.	d.
(1)							
1852	1	By Sundries	—	1523	6		6
Jan.	31	By Profit and Loss for net gain	14	8	11		1
				1531	17		7
(2)							
1852		CONTRA.	Cr.				
Jan.	2	By Johnson & Co.	10	50	0		0
	7	By Alum	3	7	16		0
	10	By Bills Payable	18	75	0		0
	14	By Wine	6	34	15		6
	20	By Tobacco	5	60	0		0
	31	By Balance in hand	18	988	11		10
				1166	3		4
(3)							
1852		CONTRA.	Cr.				
Jan.	19	By Cash, 4 cwt., at 15s.	2	3	0		0
		By Balance, 28 cwt., at 12s. 8d.	18	14	1		9
		27		17	1		9

the business in general, and an accurate state of the "balance" on closing the accounts for commencing another

		DR.	fo.	£	s.	d.
(4)	1862	COPPERAS.				
Jan.	1	To Stock, 17 cwt., at 5s. per cwt.	1	4	5	0
	31	To Profit and Loss gained	14	1	10	4
		17		5	15	4
(5)	1862	TOBACCO.				
Jan.	1	To Stock, 9 cwt., at 8s. per lb.	1	151	4	0
	20	To Sundries, 10 cwt., at 3s. 6d. per lb.	14	196	0	0
	31	To Profit and Loss gained	14	28	0	0
		19			4	0
(6)	1862	WINE.				
Jan.	1	Port. Sherry.				
	6	To Stock, 2 pipes, at £72, 5 hhds. at £40	1	364	0	0
	13	To Murray & Co., 1 pipe at £80	12	80	0	0
	14	To Bills Payable 3 hhds. at £40	13	120	0	0
	31	To Cash, Customs, &c.	2	34	15	6
		To Profit and Loss gained on the amount sold	14	6	0	0
		3 9		604	15	6
(7)	1862	THOMAS GRAY.				
Jan.	1	To Stock	1	132	2	6
				132	2	6
(8)	1862	JAMES WILSON.				
Jan.	1	To Stock	1	150	0	0
(9)	1862	BILLS RECEIVABLE.				
Jan.	1	To Stock, for Mason's accep., due 8th Jan.	1	150	0	0
	12	To Tobacco, for T. Meekin's Bill at 3 months	5	95	4	0
				245	4	0
(10)	1862	JOHNSON & Co.				
Jan.	2	To Cash	2	50	0	0
(11)	1862	JOHN SMITH.				
Jan.	3	To Copperas	4	2	2	0
	31	To Balance	18	17	18	0
				20	0	0
(12)	1862	MURRAY & Co.				
Jan.	31	To Balance	18	115	0	0
				115	0	0

set of books. The entries in the Ledger are merely transcripts of those in the Journal collected under their respective

		CONTRA.	Cr.	fo.	£	s.	d.
(4)	8	By John Smith, 6 cwt., at 7s.		11	2	2	0
1852	19	By Cash, 11 cwt., at 6s. 8d.		2	3	18	4
Jan.		17			5	15	4
(5)		CONTRA.	Cr.				
1852	8	By Cash, 5 cwt., at 3s. per lb.		2	84	0	0
Jan.	12	By Bills Receivable, 4 cwt., at 4s. 8d.		9	96	4	0
	31	By Balance, 10 cwt., at 3s. 6d.		18	196	0	0
		19			375	4	0
(6)		CONTRA.	Cr.				
1852		Port. Sherry.					
Jan.	15	By Profit and Loss 1 hhd., at £40		14	40	0	0
	19	By Cash, 2 pipes, at £75		2	150	0	0
	31	By Balance, 1 pipe, at £80 7 hhds., at £40		18	414	15	6
		1 hhd. at £54 15 6 }					
		3 9			604	15	6
(7)		CONTRA.	Cr.				
1852	5	By Cash		2	50	0	0
Jan.	31	By Balance		18	82	2	6
					132	2	6
(8)		CONTRA.	Cr.				
1852	21	By Sundries		—	150	0	0
(9)		CONTRA.	Cr.				
1852	9	By Cash, for Mason's Bill		2	150	0	0
Jan.	31	By Balance, for Meekin's Bill, due 12 April		18	95	4	0
					245	4	0
(10)		CONTRA.	Cr.				
1852	1	By Stock		1	50	0	0
(11)		CONTRA.	Cr.				
1852	1	By Stock		1	20	0	0
					20	0	0
(12)		CONTRA.	Cr.				
1852	1	By Stock		1	35	0	0
Jan.	6	By Wine		6	80	0	0
					115	0	0

heads. These accounts are usually classed under three heads :
 1st. *Personal accounts*, or such as are kept with persons or companies with whom there are dealings on credit ; 2nd. *Real accounts*, or those which relate to property of any kind,

(13) 1852 Jan.	10 31	BILLS PAYABLE. Dr.	fo.	£	s.	d.
		To Cash, for my accep. to J. Reid	2	75	0	0
		To Balance, my Bill to Williams & Co., due 13th April	18	120	0	0
				195	0	0
(14) 1852 Jan.	15 31 "	PROFIT AND LOSS. Dr.				
		To Wine	6	40	0	0
		To James Wilson	8	37	10	0
		To Stock for my net gain	1	8	11	1
				86	1	1
(15) 1852 Jan.	17	WESTMINSTER BANK. Dr.				
		To H. Adams & Co.	16	100	0	0
(16) 1852 Jan.	31	HENRY ADAMS & CO. Dr.				
		To Balance	18	100	0	0
(17) 1852 Jan.	31	THOS. HARDING Dr.				
		To Balance	18	136	0	0
(18) 1852 Jan.	31	BALANCE. Dr.				
		To Cash in hand	2	988	11	10
		To Alum, 23 cwt. at 12s. 3d.	3	14	1	9
		To Tobacco, 10 cwt. at 8s. 6d. per lb.	5	196	0	0
		To Wine, 1 pipe Port £90 0 0				
		7 hhd. Sherry, at £40 280 0 0				
		1 do. 54 15 6				
			6	414	15	6
		To Thomas Gray	7	82	2	6
		To Bills Receivable for Meehin's Bill, due 12th April	9	95	4	0
		To Westminster Bank	15	100	0	0
				1840	15	7

including ready money, which is entitled "Cash," 3rd. *Accounts of Stock, Profit and Loss, Balance, &c.* which are called fictitious or *imaginary accounts*. It is important that there be a full and correct *Index* to the Ledger.

		CONTRA.	Cr.	fo.	£	s.	d.
(13)	1862						
Jan.	1						
	13	By Stock, my Bill to J. Reid, due 10th Jan.		1	75	0	0
		By Wine, for my accep. to Williams & Co., at 3 months		6	120	0	0
					195	0	0
(14)	1862	CONTRA.	Cr.				
Jan.	16	By Cash		2	50	0	0
	31	By Alum		8	0	10	9
	"	By Copperas		4	1	10	4
	"	By Tobacco		5	28	0	0
	"	By Wine on amount sold		6	6	0	0
					86	1	1
(15)	1862	CONTRA.	Cr.				
Jan.	31	By Balance		18	100	0	0
(16)	1862	CONTRA.	Cr.				
Jan.	17	By Westminster Bank		15	100	0	0
(18)	1862	CONTRA.	Cr.				
Jan.	20	By Tobacco		5	186	0	0
(18)	1862	CONTRA.	Cr.				
Jan.	31	By John Smith		11	17	18	0
	"	By Murray & Co.		12	115	0	0
	"	By Bills Payable, for my Bill to Williams & Co., due 13th April		13	120	0	0
	"	By Henry Adams		16	100	0	0
	"	By Thomas Harding		17	136	0	0
	"	By Stock, for my Net Capital		1	1851	17	7
					1840	15	7

CHAPTER VI.

CHEMISTRY.*

CHEMISTRY is the science which treats of the composition of bodies and the changes they are undergoing. It is divided into *Organic* Chemistry, treating of organised bodies, such as plants and animals; and *Inorganic* Chemistry, treating of unorganised bodies, such as minerals and factitious products; the latter division being farther subdivided into *Analytical* and *Synthetic*, or the art of separating and the art of combining bodies; the subject of the gases being sometimes kept separate under the head of *Pneumatic* Chemistry. The applications of this beautiful science to the arts of life are so numerous, as to take in nearly the whole circle of manufacturing industry. For the purposes of the present work, how-

* Brande defines chemistry as "an art, which teaches us the properties of the elementary substances, and of their mutual combinations. It inquires into the laws which affect, and into the powers which preside over their union; it examines the proportions in which they combine, and the modes of separating them when combined; and endeavours to apply such knowledge to the explication of natural phenomena, and to useful purposes in the arts of life." The extensive range which the different parts of this science take, renders it impossible to give even an elementary explanation of its principles. The present chapter is, in fact, intended chiefly as a vehicle for the introduction of some matters connected with the duty of an excise officer, which could not conveniently be classed under the foregoing heads; but which, as they are mostly connected with the science of chemistry, are brought together under this designation. The directions given will enable the officer to make a few experiments relating to the processes with which his business is connected, and to assist him in detecting adulterations. Should he wish to extend his inquiries farther, he must consult works written expressly upon the science. A useful text book on inorganic chemistry is that written by *Dugald Campbell, Esq.*, late of the University College, London; see also, *Chemical Experiments*, by G. Francis, F.L.S.; *Dr. Ure's Dictionary*; *Stockhardt's Chemistry*, &c.

ever, it will be sufficient to advert to its use in the manufacture of certain articles which are chargeable with excise duties, as malt, spirits, soap, paper, sugar, and hops; and in detecting adulterations in some other commodities which are subject to excise regulations, as beer, tobacco, tea, coffee, cocoa, and pepper.

For operations on the most limited scale, it is necessary to be provided with a correct *Balance* * or other instrument for

* The *balance* is to the chemist what the compass is to the mariner, for no systematic method of chemical study could have been pursued without it. It is the standard as well as the test of chemical experiments; it teaches us how to ascertain the true composition of bodies, and shows us whether the questions, the answers received, or the conclusions drawn from them are correct or false. A balance consists of a brass beam, with arms of equal length, through the centre of which passes a steel wedge-shaped axis, resting on a hardened plate, so that the beam, to the extremities of which the scales are attached, may easily vibrate. It is essential that the axis should be in the right place of the beam, a little above its centre of gravity. The centre of gravity can be found by balancing the beam on its flat side, with the index attached to it, on a needle; and when the beam rests horizontally, the point of the needle designates the centre of gravity. If the axis be placed too low, *beneath* the centre of gravity the beam will overset, if one of the scales is more heavily loaded than the other. If placed directly in the centre of gravity, the balance itself will cease to vibrate when the beam is in an oblique position. When the axis is too high above the centre of gravity, the balance loses much of its sensibility. This latter defect occurs most frequently, but is easily remedied by lowering the axis. The best mode of testing the accuracy of the balance is, to change the weights from one scale to the other. For common experiments an apothecary's balance is all that is requisite.



Specific gravity, as has already been stated (p. 22), is the weight of any body compared with an equal bulk of water. Ice floats in water; iron sinks in it, because the former is lighter, the latter heavier, than water. But if we put a piece of ice in spirits, it sinks; or if we put a piece of iron upon quicksilver or mercury it floats; consequently, ice is heavier than spirit, iron lighter than quicksilver. It also follows that spirit is lighter than water, since it can support less weight; and quicksilver heavier than water, as it can bear a greater weight. The terms "heavier" and "lighter," in this sense, correspond to what in scientific language is called, *specifically heavier*, or *specifically lighter*. And *equal bulks* are always to be understood, in speaking of the comparative weights of bodies. The expression, "ice is lighter than iron," means, therefore, that taking equal bulks of each, the former weighs less than the latter; and when we say that quicksilver is heavier than water, we mean, that in equal volumes—as a pint, for instance,—the quicksilver has a greater weight than the water. But in absolute weight no regard is paid to the volume of substances. In order to ascertain *how many times* heavier quicksilver is than water, or iron than ice, it is only neces-

ascertaining the weight and specific gravity of the bodies to be examined, and with *Retorts*, or other apparatus for condensing, evaporating, or distilling the articles to be analysed.

sary to weigh equal volumes or portions of each, and compare their weights. If, for example, we take five vessels, each of which would contain exactly 1000 grains of water, and fill them respectively with spirit, ice, water, iron, and quicksilver, the following differences of weight will be found : the vessel filled with spirit would weigh in round numbers 800 grains ; with ice, 900 grains ; with water, 1000 grains ; with iron, 7500 grains ; with quicksilver, 13,500 grains. To facilitate the comparison of the numbers which denote how much greater the specific gravity of one body is than that of another, water has been fixed upon as the standard or unit. Therefore, in the above case, the question is, how much lighter than water are spirit and ice, and how much heavier are iron and quicksilver ; or, in other words, how many times is 1000 contained in 800, 900, 7500 and 13,500 ! The other numbers are then to be divided by 1000, the weight of water, and there is found for—

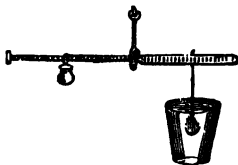
Spirit, $\frac{800}{1000} = 0.800$; it is therefore $\frac{1}{10}$ lighter than water.

Ice, $\frac{900}{1000} = 0.900$; it is therefore $\frac{1}{10}$ lighter than water.

Iron, $\frac{7500}{1000} = 7.500$; it is therefore $7\frac{1}{2}$ times heavier than water.

Quicksilver, $\frac{13500}{1000} = 13.500$; it is therefore $13\frac{1}{2}$ times heavier than water.

To determine the specific gravity of a fluid, a vial is weighed, filled with water, and then again weighed. The difference gives the weight of the water. Now pour out the water and refill the vial either with spirits, worts, beer, syrup, or some other liquid, and ascertain the weight of each. Then divide the weight of each of these fluids by the weight of the water, and the quotient indicates the specific gravity. It is very convenient to use a vial made to contain exactly 1000 grains of water, as then, without any calculation, the number of grains which such vial contains of any liquid expresses its specific gravity. The specific gravity of a fluid can also be ascertained by finding how much a given solid loses of its absolute weight by being weighed in it (pp. 24, 42). The specific gravity of a solid may also be ascertained by finding how much of its absolute weight is lost by weighing it in a fluid of known gravity (*ibid*). Various modes have been adopted for ascertaining these relative weights, one of which is the *Hydrostatic Balance*, which differs from a common balance chiefly by having a small hook under its scale, from which hook is suspended, by means of a horse-hair, the different articles to be tried, so that they may be immersed in water without wetting the scale. A species of steel-yard balance is sometimes employed, as represented in the margin. The principle upon which these operations depend is as follows. Every substance becomes lighter in water, in proportion to the amount of water displaced. If it displaces less water than its weight in the air, it sinks ; if more, it floats. Even very heavy bodies can be made to float by increasing their volume. But the same body will sink to a greater or less depth in different liquids : deeper in the lighter ones, and not so deep in those which are denser. This has suggested a very convenient instrument for determining the specific gravity of liquids, the *Hydrometer* or aerometer, an instrument which consists of a hollow tube, to cause it to float, the under part being loaded with quicksilver, to give it a vertical position, and having at the top a graduated scale, to indicate to what depth it sinks in the fluid, the specific gravity of which is under consideration. The strength of spirits is ascertained by a hydrometer of this kind.



I. MALT.

The manufacture of malt* is a chemical process for converting raw grain into a saccharine substance, to be after-

Another instrument of this description is the *Saccharometer*, which, as its name imports, is a measure of sweetness or saccharine matter, and which is calculated to show the specific gravity of worts or wash, instead of spirits, upon the principle the converse of that which is applied to spirits; for as spirituous liquors are strong in proportion to their levity, and weak in proportion to their gravity, and the hydrometer, therefore, sinks deeper in strong than weak spirits: so, on the other hand, worts are weak in proportion to their levity, or strong in proportion to their gravity; and the saccharometer, therefore, sinks deeper in weak than in strong worts. The hydrometer and saccharometer used for Revenue purposes are described under the head "Spirits." (*Infra*. pp. 198, 203.)

Evaporation consists merely in subjecting a solution to such a degree of heat as will enable it to part with the whole or a portion of its moisture, thereby enabling solutions of metallic and other salts to crystallise, decoctions to become thicker and more concentrated, and precipitates to lose their adherent moisture and to become dry. In subjecting a substance to evaporation, no notice is ordinarily taken of the vapour which flies off. If the liquid is to be preserved, the process is called *Distillation*.

This process is conducted in close vessels with some contrivance annexed to them for condensing the steam which arises, and retaining the liquid which flows from it. The general nature of distillation will be understood by its application to water, which should always be used in a distilled state for a chemical experiment. To make this in sufficient quantity, a small glass retort is half-filled with water and heated by means of a spirit lamp placed underneath it, as in the margin. The retort is fixed into the end of a glass receiver, and luted to it by means of a mixture of flour and whiting, of equal parts, and one-tenth of its quantity of salt, with water to make it into a paste. The steam from the water, as it forms, passes through the neck of the retort into the glass receiver, which is placed in a vessel filled with cold water, and is there condensed. That the refrigeration may take place more rapidly, the receiver is covered with coarse blotting paper, which is frequently moistened by cold water. The distilled water obtained by the process is purer than spring water, for this reason, that the non-volatile, earthy, and saline portions contained in all spring water, do not ascend with the vapour, but remain in the retort. Water may also be distilled in a common still, such as is used for distilling spirits (p. 199).

* Malting is the process of preparing barley or other grain for brewing or distillation. As these results can only be obtained from a saccharine basis, (that is a substance possessing the nature of sugar), the starch of the barley must first be converted into this saccharine matter before the final change into ale or spirits can be obtained. As the chemical change from starch to saccharine matter is found to exist to the greatest extent in all seeds when they begin to vegetate for the purpose of growth and reproduction, it became desirable to form an artificial process of vegetation as nearly resembling the natural as possible; and this has been done in the various stages of malting.



wards used in the brewing of beer or the distillation of spirits. For this purpose the grain is made to vegetate artificially to a certain extent, by steeping it in water and

As vegetation cannot occur without heat and moisture, it is the object of the maltster to supply both of these in such proportions as are requisite for the natural budding and growth of new roots and leaves. For this purpose, the dry barley is first put into a *cistern* containing as much cold water as will cover all the barley introduced. Here it must remain till it is sufficiently saturated (which by law cannot be less than 40 hours), but the precise time it should remain depends on the state of the atmosphere and the quality of the barley. Should the weather be very cold, and the grain dry and hard, it has been known to require 92, 98, and sometimes 112 hours steeping, as is the case in the north of Scotland. The water first introduced is usually drawn off, and a fresh supply substituted during the process. During the steeping, three changes take place in the grain : 1, It imbibes moisture and increases in bulk ; 2, Carbonic acid gas is generated, some of which is evolved, but the greater portion of it remains in the steep water ; 3, A portion of the husk or skin of the barley is dissolved, in consequence of which the steep water acquires a yellow colour, and contracts a peculiar smell. The quantity of moisture imbibed depends generally upon the goodness of the barley, and the length of time it remains in steep. The swell may be reckoned in general at one-fifth of the original bulk, or, according to the legal allowance, $18\frac{1}{4}$ bushels for every $81\frac{1}{4}$ of dry barley wetted.

When the barley is judged by the maltster to have remained long enough in steep, which is the case when the two ends can be squeezed together between the finger and thumb, the water is let off, and the grain allowed to drain. It is then thrown into the *couch-frame*, a rectangular vessel, or a portion of the malthouse partitioned off, where it forms a heap, usually about 16 inches deep, and remains at least 26 hours, or 30 if not sooner gauged by an officer. It is then deemed to be a *floor*, and being spread upon the ground is from time to time turned with a wooden shovel, an operation which is called "working on the floor." Here, the maltster is not allowed to wet or sprinkle it with water before it has been 12 days, or 288 hours, out of cistern ; unless it has been kept in the cistern 50 hours, in which case he is allowed to sprinkle it, on notice, at the end of 6 days, or 144 hours. During the first three or four hours after the grain has been thrown out of the cistern, it feels dry, the external moisture being either absorbed or evolved, and the temperature is the same as in the cistern ; but, afterwards, a gradual increase of heat becomes perceptible, and continues to rise till the temperature of the grain is about ten degrees higher than the atmosphere. This takes place about 96 hours after the grain has been thrown out of steep, and at this time it exhales an agreeable odour, something resembling that of apples, and has become moist. This is called *sweating* by the maltster, and forms an important stage in the process of malting. The action of heat upon the moist barley causes the saccharine fermentation which results in the protrusion of roots ; in bear or big, the rootlets amount to three, and in barley to five or six. These rootlets increase in length rapidly, and the principal art of the maltster is directed to keep them short till the grain is sufficiently malted, as a great part of the saccharine particles of the malt would be otherwise conveyed into the roots, and finally lost. The temperature requires also to be checked ; for, if allowed to continue, it would run so high as to char the grain, if not to set it on fire ; at any rate, it would completely stop the process of the saccharine fermentation. To accomplish these purposes, the grain is turned upon the floor regularly, and laid thinner at every turning, till it is reduced from about

afterwards spreading it out in heaps or floors of various thicknesses, the vegetating process being stopped at a certain point by the application of heat. The chief object of the

16 inches to 3 or 4 inches, the number of turnings being regulated by the temperature of the grain, but seldom fewer than two each day. In England, the temperature of the grain on the floor is kept as nearly as possible at 60°, and in Scotland at about 55°. While the grain is on the floor it absorbs oxygen gas, and emits carbonic acid gas. About a day after the sprouting of the roots, the rudiments of the future stem, called *acrospire* by the maltsters, may be seen to lengthen. It rises from the same extremity of the seed with the root, as at *a*, and, turning round, advances within the husk, through the body of the grain, and at last issues from the opposite end, at *b*; but the process of malting is stopped some time before the stem has made such progress as to burst the husk. As the *acrospire* shoots along the grain, the appearance of the kernel or mealy part of the corn, undergoes a considerable change. The glutinous and mucilaginous matter in a great measure disappears, the colour becomes whiter, the taste is sweet, and the texture so loose that it crumbles to powder between the fingers. The whole art of malting depends on the proper regulation of these changes. The time that grain is kept on the floor varies according to circumstances. The higher the temperature at which it is kept, the more speedily it is converted into malt. In general 14 days in England, and 18 in Scotland, may be specified as the average time, but maltsters differ much in their mode of working, and consequently in the time employed for completing the process.



After the corn has been sufficiently worked on the floor, to stop the germination it is dried on a *kiln* with a perforated bottom, which is heated to the requisite degree by a fire beneath. At first the temperature is not higher than 90°, but it is elevated slowly to 140° or upwards. The great secret in drying malt properly, consists in keeping the heat very low at first, and raising it gradually as the moisture is dissipated; for a higher temperature would infallibly blacken or even char the malt, and would certainly diminish considerably the quantity of soluble matter which it contains; but as a general rule, it may be observed, that the more rapidly malt is dried off, the more its bulk increases. The time of kiln drying varies according to the quantity of grain exposed to the action of the heat. For brewing malt the average may be taken at two days. In drying *pale* malt it is laid thick upon the kiln and the fire is applied more gradually than for *brown* malt, the colour of which is imparted by a strong fire towards the end of the drying process. In drying *porter* malt, it is laid quite thin upon the kiln, and while one man keeps stirring it, another is applying a strong wood fire to it, which is called "snapping malt." After the fire is withdrawn, the malt is allowed to remain on the kiln till it becomes nearly cold. By the kiln drying all vegetation is not only stopped, but the roots of the barley, or, as the maltsters call them, *comings* or *coombs*, are dried up and fall off. They are separated from the malt by passing over the surface of a kind of wire sieve, which allows the *comings* to drop through.

In the course of the malting process, the grain thus undergoes a remarkable change. At first it consists entirely of starch, agglutinated in the grain, so as to make a solid and very firm mass; but in the malt it is quite loose and mealy. Hence it would appear that the glutinous and mucilaginous matter of the barley is chiefly employed in forming the roots; but how far the starch is altered into the saccharine state has not been definitely ex-

officer's survey of this commodity is to prevent the introduction of grain that has not been charged with duty.

To ascertain whether barley has been irregularly introduced

plained. Dr. Ure states that the substance of the grain is converted into saccharine matter as far as the acrospire proceeds, and that that part of the grain to which it has not reached remains unchanged in a starchy state.

It has been estimated that a quantity of good barley which weighs 100 lbs. being judiciously malted, will weigh, after drying and sifting, 80 lbs. Since the raw grain, dried by itself at the same temperature as the malt, would lose 12 per cent. of its weight in water, the malting process dissipates out of these remaining 88 pounds, only 8 lbs. or 8 per cent. of the raw barley. This last consists of:—

1½	per cent. dissolved out in the steep water,
3	„ dissipated in the kiln,
3	„ by the falling of the fibrils,
½	„ of waste.

Bear or big malt sustains a loss of weight of about 15 per cent.

The *bulk* of good malt exceeds that of the barley from which it was made by about 8 or 9 per cent.

The following are the results of Dr. Thomson's analysis of barley and the malt made from it:—

	Barley.	Malt.
Gluten	3	1
Sugar	4	16
Gum	5	14
Starch	88	69
	100	100

In order to discover whether grain has been fraudulently introduced, the officer should make himself perfectly acquainted with the nature and effects of the different parts of the operation. He will thus be enabled by experience to know the exact age of the grain in any part of the process and distinguish it from grain of any other age or steeping. The amount of his different gauges will also be a criterion of the honesty of the trader.

The principle upon which the different allowances are made upon malt in its various stages of operation is a presumption, as already stated, that 100 cistern or couch bushels, or 163 floor bushels, gauged after the grain has been emptied from the cistern, will make only 81·5 net bushels. The mode of making calculations on this subject is as follows:—*To reduce any given number of cistern bushels to their equivalent in dry malt.*—Multiply the cistern or couch bushels by ·815, and the product will be the equivalent in net bushels, (p. 101.) *To reduce any number of floor bushels to net bushels.*—Multiply the given number of floor bushels by ·5, the product will be the equivalent number of net bushels. *To find whether a floor gauge will produce a better charge than the cistern or couch bushels to which such floor belongs.*—Multiply the amount of the best cistern or couch gauge by 1·63, and if the product be equal to, or exceed the amount of the floor gauge, the best cistern or couch gauge will be the charge; but if that product be less than the amount of the floor gauge, the floor gauge will be the charge; as in the following examples:—

The best cistern gauge of a steeping of barley was taken on October 18, m. p. 5, amounting to 98 bushels, and couch gauges of the same taken on 18 m. p. 9, and 19 m. p. 9, each amounted to 100 bushels; a floor gauge taken 28 m. p. 8, amounted to 166·9 bushels; from which of the gauges does the charge arise, and what are the net bushels?

*into a floor of malt.**—Take a sample of the suspected grain and put it into water; if any portion sink to the bottom much sooner than the other, it is an indication that the grain has not all been steeped at the same time.

100 (best couch) $\times 1.63 = 163$, which, being less than 166.9, leaves the best charge on the floor; therefore, the best cistern or couch gauge is cancelled in the Survey-book, and the best floor gauge left. Then, $166.9 \times .5 = 83.45$, the net bushels to be charged.

If the best floor gauge, taken as above, had been 160, the charge would arise from the best couch gauge, that being greater than the equivalent floor gauge, and the net bushels in such case would be $81.5 (= 100 \times .815)$.

If the Officer require to know readily whether the charge will be on the cistern or floor, a near approximation to the true quantity may be obtained mentally as follows:—Multiply the couch bushels by .6, and add the product to the couch bushels: thus, in the foregoing example, $100 \times .6 + 100 = 160$. Then, if greater accuracy is required, add 3 bushels for every 100 couch bushels; thus, $160 + 3 = 163$ as above. When the quantity is not an even 100, a proportionate amount must be added, as 1.5 for every 50; .3 for every 10, &c.

* All sorts of practices are resorted to for the purpose of smuggling the grain through the malthouse without being properly charged with duty. Sometimes the grain is wetted in a private place and brought in as occasion offers, and mixed with the other floors. Sometimes a portion of the grain is privately taken out of the cistern after it has been steeped a certain time, and added to the youngest floor; the deficiency in the cistern being met by the addition of dry barley from the chamber; this is called "robbing the cistern." In some instances the grain privately steeped or conveyed away is concealed under a surface of dry barley in the bins; and in others it is put into sacks, and placed with sacks of dry grain until room is made for it in the entered malthouse, where it is sometimes laid in the place of a depending couch, which has been artfully forwarded on the floor, or mixed with the younger floors, and then mixing these, or a portion of them, with or amongst the older floors. And, to prevent the increase occasioned by these frauds from being discovered, the kiln, which has been made purposely large, is fed with a brisk fire, and the excess occasioned by the fraudulent introduction dried off in the night, or between the Officer's visits. Sometimes fraudulent maltsters heap their young floors, or lay them thick to force the vegetation, and thereby deceive the Officer. In order to prevent or detect these practices, the Officer is required by his instructions to take samples of the grain from several parts of the cistern, especially when the grain purports to have been kept an unusual length of time in it, and by biting and otherwise carefully examining it, ascertain whether it be harder or less saturated than it otherwise ought to be. He is also to observe whether the water in the cistern be warm, or whether there be an unusual space left between the cistern and the youngest floor, or between that and the next oldest floor, and whether the kiln be charged high, and fed with a brisk fire; he is likewise carefully to examine the grain on the floor, and observe whether any extraordinary increase has taken place, especially after the fifth and sixth days after being emptied from the cistern; and to observe whether there be any new wettings laid between the old ones, or any addition made to any of the depending floors; and whether any couch or floor has been illegally watered or sprinkled; and to examine particularly the corn on the kiln, in order to discover whether there be any diversity in its growth and appearance. Should any illegal mixture be suspected, the rule

To find whether grain has been properly dried on the kiln.

— Take a sample of the suspected grain and sow it on a flannel or in a garden pot ; if it grow like barley, it is an indication that it has not been properly worked and dried on the kiln.*

in the text affords a useful criterion for testing the correctness of the suspicion, but it cannot be relied on as evidence of any illegal mixture without, at least, being confirmed by other testimony. When, therefore, an Officer has satisfied himself that the house is fraudulent, he should make sudden and unexpected returns to it, and survey late in the evening and early in the morning, or cautiously watch the proceedings of the maltmen until the fraud is detected.

When a house is worked honestly, the charge of duty is usually on the couch, and if the swell there does not show an increase of at least 23 per cent. upon the dry barley, it is an indication, under ordinary circumstances, that fraud has been resorted to. This is a most useful criterion, and may be ascertained by multiplying the first cistern gauge by 1·23, as in the following example. The first dip in the cistern, one hour wetted, was 15 inches, the area of the cistern being $4·80 = 72$ bushels; this quantity being multiplied by 1·23 gives 88·56, the quantity which ought to be in the couch, at least. Then suppose the area of the couch to be 8·41 and the dip $10·7 = 89·987$ bushels. This shows that the couch contains 1·427 bushels, more than 23 per cent. upon the dry barley. If in this case there had been less than 88·56, the increase would have been unsatisfactory. The operations may be readily performed on the sliding-rule by the lines A and B (p. 57).

To evade the charge falling upon the couch, maltsters frequently resort to the practice of treading or pressing the malt in that stage, especially about the sides and edges, where the dips are not usually taken. The only effectual way of preventing this is, for the Officer to be present as often as possible when the corn is thrown out. The legal test for ascertaining whether the corn has been unduly compressed, is to throw the corn out of the couch and return it again, and if an increase be found over the first gauge in any greater proportion than 5 per cent. before it shall have been emptied 8 hours, or 6 per cent. before it shall have been emptied 16 hours, or 7 per cent., if it shall have been longer emptied, it is deemed conclusive evidence that the grain had been trodden, and subjects the party to a penalty of £100.

To discover privately-steeped grain, the Officer is likewise required to examine the several parcels of dry barley in the malthouse, and ransack the dry barley in the malt store-rooms, and bins, and the adjacent outhouses, &c. ; and should any of the sacks feel damp or moist, he should examine the contents. He is also to search for private and concealed utensils and places for steeping corn, and rooms or places for making malt or laying it in. And for this purpose he is to be careful to observe that there is no door, cupboard like the wall, no range of boards to be taken down, nor any private passage from the malthouse to any other place. And whenever he shall have cause to suspect fraud, by running of floors or otherwise, he is to take gauges of all the depending floors, and samples of them, if necessary, which should be kept in separate bottles closely corked and sealed down, and locked up under his own especial care.

* It must be observed that the vegetation of the malt is not *conclusive* evidence of its not having been dried upon the kiln. Mr. Farey states that he has taken malt dried at the temperature of 175° , put it into a garden pot filled with soil, and seen it vegetate apparently as well as raw grain placed in the same situation. But he admits that malt, reduced to the colour of burnt coffee by heat, would be deprived of the power of vegetating : and, as a

II. SPIRITS.*

Spirits are produced by Distillation, which is a chemical process whereby a fluid is converted into vapour by means of heat, and that vapour turned into a state of fluidity by

general rule, it may be laid down, that when malt has been regularly worked and dried upon the kiln, its power of vegetating is gone; or, at all events, if a thin blade should spring up, it will wither away, after growing two or three inches.

* The following account of the mode in which spirits are manufactured in this country is founded partly on an excellent article on distillation in the *Encyclopædia Britannica*; but it must be observed that the process varies in different parts of the country, and even in different distilleries in the same locality; and improvements in this really scientific art are so rapid and various, that it is impossible to say what particular mode of operation is adopted in any given distillery. The processes described, however, will explain the general principles on which distillation is based.

It seems established, by the experiments of chemists, that no other substance can be converted into spirits by fermentation than sugar; and that, therefore, all bodies, from which spirits are extracted, must first be changed into a saccharine basis, if they have not such already, before undergoing the process of distillation. Extracts from different saccharine bases have different names, according to the particular kind of sugar they were reduced from: thus the spirit derived from the refuse of common sugar is called "rum;" from wine, "brandy;" and from grain—as barley, &c., "malt-spirits," or "whiskey." The substances employed in this country in the manufacture of spirits upon the great scale are different kinds of corn, such as barley, rye, wheat, oats, buck-wheat, and maize. Peas and beans have also been occasionally used in a small quantity. Sometimes sugar or molasses is employed; but as this is only to a limited extent, it is considered best to confine the description of the process to the distillation of spirits from different kinds of grain. The principles in these grains, from which the spirits are indirectly produced are starch and a little sweet mucilage, which, by a peculiar process, called "mashing," are converted into a species of sugar. The sugar so formed is the immediate generator of alcohol, by the process of fermentation. The alcohol is separated from the liquor in which it is fermented by distillation. The manufacture of whiskey or ardent spirits, therefore, consists of three distinct operations, viz., *Mashing*, *Fermentation*, and *Distillation*.

MASHING.

Malting is the most effectual method of converting starch into sugar; and, therefore, the grain used for making spirits is usually either malted or mixed with malted grain. The process of malting (see p. 189) has the effect of converting the greater part of the grain into sugar; but a portion of it remains in a state of starch, and requires to be mashed, in order to its complete conversion into saccharine matter. The grain is coarsely ground or bruised, and put into a vessel called a *mash tun*, along with a proper proportion of hot water, and the mixture is subjected to agitation by a mechanical revolving apparatus, similar to that employed in beer breweries. Much importance is attached to the quantity of water, and the heat at which it is put in, as it is impossible to extract the proper quantity of worts at the required gravity without these matters being duly attended to. When malt alone is used, the water first run into the mash tun has usually a temperature of 160° or 165°;

means of cold. The basis of all spirits is a saccharine matter, and the materials most commonly used in the United Kingdom for producing such spirits are malt, barley, and other kinds of grain. For converting the

but when a considerable portion of raw grain is mixed with the malt, the water is let on at a lower temperature, from 145° to 155° , to prevent the formation of such a pasty composition as would not allow the worts to run off readily. The following are the quantities of malt and raw grain mixed, which have been found to afford a good product of whiskey in a well-conducted Scotch distillery :—

252 bushels of malt at 40 lbs. per bushel.			
948	„	barley,	$53\frac{3}{4}$ „
150	„	oats,	$47\frac{1}{4}$ „
150	„	rye,	$53\frac{3}{4}$ „

From each bushel of this mixture, $2\frac{1}{2}$ gallons of proof whiskey, specific gravity $\cdot 920$, may be obtained, or $18\frac{3}{4}$ gallons per quarter. A few distillers are skilful enough to extract 20 gallons from a quarter of the mixture. 10 gallons may be considered a fair proportion of water to be introduced into the mash tun for every bushel of meal at the first infusion. After 2 or 3 hours agitation, the whole is left to repose for an hour and a half; and then the worts are drawn off, over the top, to about $\frac{1}{3}$ the volume of water employed; the rest being entangled in a pasty state among the farina. About $\frac{2}{3}$ of the first quantity of water is now let into the tub, but at a temperature somewhat higher, and the mashing motion is renewed for nearly half an hour. A second period of infusion or repose ensues, after which these second worts are drawn off. Both infusions must be cooled as quickly as possible down to the temperature of 80° or 70° , otherwise they are apt to run into the acetous fermentation, by the rapid absorption of atmospheric oxygen. This refrigeration is usually effected by exposing the wort for some time in large shallow cisterns, called *coolers*, placed near the top of the building, where it may be freely exposed to the aerial currents. But it is sometimes cooled by being passed through serpentine tubes, surrounded with cold water, or by the agency of ventilators blowing over its surface in extensive cisterns, only 3 or 4 inches deep. After the second wort is drawn off, a third quantity of water, fully as great as the first, but nearly boiling hot, is run into the mash tun, and incorporated with the pasty substance by agitation; after repose, a third wort is also drawn off, cooled, and either directly mixed with the preceding worts or after it has been concentrated by boiling down; in most cases, however, it is reserved, and used instead of water for the first infusion of a fresh quantity of meal.

The density at which worts may be let down into the fermenting tuns must in England be between $1\cdot 050$ and $1\cdot 090$; and in Scotland, between $1\cdot 030$ and $1\cdot 080$, which, for sake of brevity, are called 50, 90, 30, and 80, omitting the 1·0, common to them all; and the distiller is required to work at the density or gravity declared, until he gives another declaration. At these densities, the quantities of solid saccharine matter contained in one barrel of 36 gallons are 47·25 lbs., 85 lbs., 28 lbs., and 75 lbs. respectively.

About 150 gallons of wort or wash are obtained from each quarter of corn employed. The first wort will have generally the density of $1\cdot 078$, when the grain is good, and the mashing is well managed; and the second, a density of $1\cdot 054$, so that the mixture will have a specific gravity somewhat above $1\cdot 060$. Every 100 gallons of wort is required to produce 1 gallon of proof spirits for every 5 degrees of attenuation which its gravity undergoes in the fermenting tun; so that if it falls from $1\cdot 060$ to $1\cdot 000$, 12 gallons of proof

materials into the state proper for distillation, they are first subjected to mashing and fermenting processes—similar to those used in brewing beer—so as to produce an alcoholic liquid called *worts*, or *wash*. After fermentation the worts

spirits are supposed to be generated, and must be accounted for by the distiller. For the mode of ascertaining the gravity of the wort, see pp. 198, 206.

FERMENTATION.

Fermentation is undoubtedly the most intricate, as it is the most important process in distillation. Experiments have proved that the quantity of saccharine matter converted into alcohol is dependent upon the proportion of ferment or yeast introduced into the worts. If too little be used, a portion of the sugar will remain undecomposed; and if too much, the spirits will contract a disagreeable taste. In general, the worts are let down into the *fermenting tun* at the specific gravity of 1·050 or 1·060, and at a temperature varying from 60° to 70°; and *yeast* or *bub* is immediately poured in and thoroughly incorporated with it by agitation with a stirrer. If yeast be used, 1 gallon of good porter yeast is put in for every 100 gallons of worts. Sometimes *bub* is used, which is made of beer and porter yeast, and a quantity of worts from the first mashing. If 60 gallons of *bub* are to be made, 40 may be worts, 5 ale yeast, and 10 porter yeast; sometimes the *bub* is made partly from ground barley. It is not allowed to be mixed if above the declared gravity.

The effect of mixing yeast or *bub* with the worts, is fermentation, which causes the specific gravity of the wort to diminish, owing to the decomposition of the saccharine matter, and its conversion into alcohol and carbonic acid, which is called by distillers *attenuation*. When, by the attenuation, the specific gravity is diminished to 1·035, one half-gallon more of yeast or *bub* is added, and another half-gallon at the specific gravity of 1·025, after which the worts usually receive no further addition of yeast or *bub*. From the appearance of the froth or scum, the experienced distiller can form a tolerably correct judgment as to the progress and quality of the fermentation. The greatest elevation usually takes place within 36 hours after the commencement of the process. The object of the distiller is to push the attenuation as far as possible, which so far differs from that of the beer brewer, who wishes always to preserve a portion of the saccharine matter undecomposed, to give flavour and body to his beverage. The first appearance of fermentation shows itself by a ring of froth round the edge of the vat, usually within an hour after the addition of the yeast, and in the course of five hours the extrication of carbonic acid from the particles throughout the whole body of the liquor causes frothy bubbles to cover its entire surface. The temperature meanwhile rises from 10° to 15°, according to circumstances. The greater the mass of liquid, the lower the temperature at which it was let down into the tun, and the colder the surrounding atmosphere, the more slowly will the phenomena of fermentation be developed, under a like proportion of yeast and density of the worts. In general, large vats afford a better result than small ones, on account of the equality of the process. It is reckoned good work when the specific gravity comes down to 1·000, or that of water, and superior work when it falls 4 or 5 degrees below it, or 0·995. After 36 hours, upon a moderate scale, the yeasty froth begins to subside; and when the attenuation gets more advanced, the greater part of it falls to the bottom, on account of its density relatively to the subjacent fluid. In from 48 to 60 hours, the liquor begins to grow clear, and becomes comparatively tranquil. It has been deemed advantageous towards the perfection of the fermentation to rouse up the wash occasionally with a proper stirrer, and in

are passed through a Still, or a succession of Stills, until, by evaporation and condensation, the spirit is obtained from the worts in a state sufficiently pure for mercantile purposes.

some cases to increase its temperature a few degrees by the transmission of steam through a serpentine pipe coiled round the sides of the vat. Some have imagined that a considerable portion of spirit is carried off by the great volume of carbonic acid gas evolved, and have proposed to save it by covering the vats air-tight, and conducting the gas through a pipe in the lids into a vessel containing water. The economy of the apparatus is not worth the expense and trouble which it occasions. Distillers content themselves with enclosing their vats after the first violence of the action, under tolerably tight covers.

In the huge fermenting vats used by the corn distillers of this country, the fermentation goes on far more slowly than when conducted upon the moderate scale referred to in the account of this process given above. About 1 gallon of yeast is added at first for every 100 gallons of wort, and a half-gallon additional upon each of the succeeding 4 days, making in the whole 3 per cent.; when less can be made to suffice, the spirits will be better flavoured. The fermentation goes on during from 6 to 12 days, according to the modifying influence of the circumstances above enumerated. After the fifth or sixth day, the tuns are covered in, so as to obstruct, in a certain degree, the discharge of the carbonic acid, as it is supposed that this gas in excess favours fermentation. The temperature is usually greatest on the fourth or fifth day, when it sometimes rises to 85° , from the starting pitch of 60° or 56° . Whenever the attenuation has reached the lowest point, ascertained by the saccharometer, the wash ought to be distilled, since immediately afterwards the alcohol begins to be converted into the acetous fermentation. This acidification may be partially repressed by the exclusion of atmospheric oxygen.

The density or gravity of wort is ascertained by an instrument called a *Saccharometer* (pp. 189, 206). Wort is heavier than water, according to the quantity of saccharine matter which it holds in solution; the weight or gravity of wort is therefore a criterion of its value, and one of the modes in which the duty is charged. The specific gravity of worts may be obtained, like that of any other liquid, from the weight which a solid body loses by immersion in it; or by use of the weighing bottle (p. 188); but this is much more readily done by the saccharometer, which is so constructed as to show the weight or density of the worts in proportion to the depth it sinks in them. The saccharometer authorised by law to be used for revenue purposes, is one patented by the late Robert Bate, Esq., and called Bate's Saccharometer. It is made of brass; the ball or float being a circular spindle, at the top of which is a stem and at the bottom a loop; the stem bears a scale of divisions numbered downwards from 0 to 30, each division indicating the one-thousandth part of the specific gravity of water. It is accompanied by 5 poises or weights, with the proper indications marked on them; which poises are to be attached to the loop at the bottom of the instrument when needed. The poises are of different weights and sizes, so as not only to make an alteration in the weight of the saccharometer, but also in its bulk; the graduations on the stem continuing to indicate the specific gravity in addition to the poise attached to the instrument. This instrument shows the true specific gravity at 60° of the wort, as compared with that of water; but the real object of its use is to ascertain in what degree the wort is *stronger* than water, it being declared by act of parliament, 6 Geo. IV., c. 80, s. 53: "that



The density or gravity of the worts is ascertained by an instrument called a *Saccharometer*, and the strength or purity of the spirit by an instrument called a *Hydrometer*.

distilled water being assumed as unity at 60° , every degree of the gravity of wort shall be correspondent to the thousandth part of the specific gravity of such water; and that all wort shall be deemed to be of such gravity as the saccharometer shall indicate." It is, therefore, necessary to deduct 1000 from the indication on the saccharometer to ascertain the degrees of gravity of any particular wort; or, in other words, to reckon the last two figures of the indication as the gravity of the worts, the whole indication being the true specific gravity at the temperature of 60° , as already stated. The instrument is furnished by the Commissioners for the use of officers at distilleries, and accompanied by a thermometer and tables, by which the true gravity at any temperature may be readily ascertained. (See examples in p. 206.)

DISTILLATION.

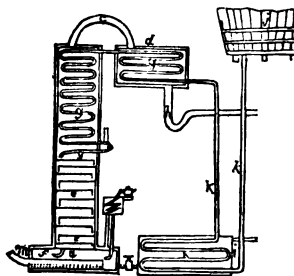
The finishing process in the manufacture of spirits is *distillation*, whereby the fermented wort or wash, having been conveyed into a *Still*, is made to boil, and the spirituous parts arising in vapour are condensed and refrigerated; and then collected into another vessel as *spirit*. There is no chemical apparatus which has undergone so many metamorphoses as the still and condenser. The old and common kind of still, as represented in the margin, may serve to give an idea of the general principles on which the apparatus is constructed, and the mode of working. A is the body of the still, or the copper in which the wash is boiled for distillation; B is the furnace for heating the liquor; C is the still head; D F is the worm, through which the spirit escapes in vapour; E is the worm tub or refrigerator, which is filled with cold water; and G is the receiver, into which the spirit passes when distilled. Great distilleries are usually mounted with two stills, a larger and a smaller. The former is the *wash still*, and serves to distil from the fermented worts a weak crude spirit called *low wines*; the latter is the *low wines still*, and rectifies by a second process the product of the first distillation. In these successive distillations a quantity of fetid oil, derived from the corn, comes over along with the first and last portions received, and constitutes, by its combination, what is styled the *strong* and *weak feints* in the language of the distillers. These milky feints are carefully separated from the limpid spirit, by turning them as they begin to flow from the worm end into distinct channels, which lead to separate receivers. From these receivers the various qualities of spirits, low wines, and feints are, for the purpose of redistillation, pumped up into *charging backs*, from which they are run, in gauged quantities, into the low wines and spirit stills. The spirit is ultimately collected in the *spirit receivers*, where it is gauged, and taken account of for charging the duty.

Coffey's Still, which is now used in many distilleries, is constructed on the following principles. It has been found that the points of temperature at which water and alcohol boil are 212° for the former, and 173° for the latter; and that mixtures of these boil at intermediate heats, in proportion to their quantities. When the steam of water is made to pass through a liquid composed of water and alcohol, it will be condensed until it has raised the mixture to its own boiling point; after which the alcohol evaporates by the further application of steam. When a mixture of steam and alcoholic vapour is made



To find the gravity of worts used for distillery purposes.—
 Pour a sample of the wort into a proof glass, and immerse

to pass through a liquid composed of water and alcohol, similar effects are produced; for after the mixture has arrived at its boiling point, the vapour passing through loses some of its watery parts, and an equivalent quantity of alcohol is volatilised, and the mixed vapour, after passing through the liquid, carries off a larger portion of alcohol than it brought with it. When a mixture of steam and alcoholic vapour passes into a condenser or worm, the vapour first condensed will contain more than a mean proportion of steam or watery vapour; and if the size of the condenser or worm be not sufficient, or the temperature of the bath in which it is immersed be too high to condense all the vapour, that portion of it which escapes uncondensed will contain more alcohol than the portion condensed. (See *Morewood on Inebriating Liquors.*) The body of the apparatus for distilling on these principles consists of an oblong vessel, and a long column erected thereon. The lower part of the column is called the *analyser*, and the upper part the *rectifier*. In some stills the analyser is placed in one column, and the rectifier in another, parallel to it. The annexed engraving represents a sectional view of that part of the still wherein the wash is deprived of its alcohol, and the vapours analysed; and may be regarded as the most simple form of the apparatus, a number of ingenious contrivances being added in detail for carrying on the process more effectively; *a* is a large chamber, sometimes divided horizontally by a perforated plate of iron with valves, and is for the reception of the spent wash after it has passed along the vermicular pipe and down the column; *m* is a pipe for admitting steam into the bottom of the vessel from a boiler placed at any distance from the apparatus. The lower half of the column is divided into compartments by horizontal metal plates, *e e*; each of these plates is turned down at one end until it nearly touches the plate next underneath, the openings being at alternate ends, thus leaving a passage throughout the whole of them, by which any liquid falling on the top plate may descend into the next under it, and from that to the third, &c., until it arrives at the last plate. These plates are perforated with very numerous holes, so very fine as only to allow of the passage of steam upwards, but not of the liquor downwards, it being allowed to fall only at the ends of the plates. Sometimes these plates are fitted up with dropping-pipes in place of the openings at the ends, through which the liquor flows from plate to plate; the upper end of the pipe projecting an inch or two above the plate in which it is inserted, so as to retain at all times a stratum of wash of that depth on each plate. The lower end of each pipe dips a little way into a shallow pan lying on the plate underneath; which pan, of course being full before any liquid flows over, the end of the pipe is constantly immersed in liquor, by which means the escape of vapour through the pipe is prevented. Besides the perforations, each plate is furnished with two valves, which open upwards when the amount of steam is too great to get through by the former process: *c* is a pipe by which the alcoholic vapour, after it has passed through the *analyser* and rectifier *g*, is conducted into the vessel *d*, which is made perfectly close. The vapour here coming in contact with the pipes in which comparatively



the thermometer, stirring the sample with it ; put the pilot into the sample, so as to ascertain what poise is to be used

cold wash is flowing, will be condensed on the surface of the pipes ; from this it descends, in a liquid state, through the pipe *k* into a refrigerator of the usual kind. The mode of action is this :—The zigzag pipes are first filled with wash from the large vessel *j*, through the pipes *k k*, which may be sent through the pipes by a force-pump, should the force of gravity not be sufficient, or the wash charger be placed lower than the top of the column. The quantity of wash introduced is regulated by a tap or cock ; and as it is necessary that the wort should not reach the boiling point while in the pipe *k*, a thermometer is placed on the pipe, and, by increasing or diminishing the quantity of wash, its temperature may be regulated. The wash thus passes through the pipes, and is discharged on the plates *e e*, till it falls into the vessel *a*, by the pipe *f*. During this process it has undergone a change. The supply of steam from the boiler enters by the pipe *m*, perforated so as to spread the steam over the vessel containing the spent wash ; and by heating it to the proper temperature, should any spirit still remain, it is disengaged, and carried up with the steam passing through the plates by small holes and valves, and through the stratum or sheet of wash which each plate contains ; the wash as it descends giving out a continuous portion of its alcohol to the steam as it passes over every plate, until the wash is entirely deprived of its spirit, which is generally the case when it has arrived at the 7th or 8th plate ; but the greater the number of plates used the better will the wash be exhausted. In some stills these plates are continued to the head of the column, the pipes passing between them ; in either form, however, the steam, still rising, surrounds the pipe at the head of the column, and, by this means, heats the wash in its passage to the plates. The same thing takes place when the steam has passed over through the tube *c* into the vessel *d*, where, meeting with still colder wash, and consequently parting with a proportionate degree of its caloric, it finally becomes condensed on these pipes, and passes out of the vessel through *h*, in a state of spirit, to the refrigerator. It will be seen that any vapour condensed, which is generally water, on the pipes in the column, will fall on the plates and mix with the wash, while that in the vessel *d* is carried off as spirit. From the vessel *a* there is a pipe with a cock to the vessel *i*, through which the spent wash, after it has remained a sufficient time to have all its alcohol abstracted, is conveyed in its boiling state to the vessel *i*, where it surrounds the pipes containing the wash, and thus commences the process of heating it. This is occasionally drawn off, and a fresh supply admitted from *a*, according as it is required, or is made to flow continuously through a pipe at the top, should no spirit descend into *a*. A small steam pipe rises from the chamber *a*, with its upper end opening into a box or chamber ; into this chamber the end of a worm projects from a cistern of cold water. The steam rising up the pipe is nearly all condensed in the worm, and flows back into *a* by the pipe. The small portion of the steam uncondensed is allowed to escape at the upper end of the worm, and the flame of a small lamp is constantly kept over the orifice ; when, should any quantity of alcohol descend with the wash into the chamber *a*, it will rise with the steam through the pipe and worm, and immediately take fire from the flame of the lamp ; thereby warning the attendant to increase the supply of steam, or diminish the quantity of wash, as may seem necessary. Sometimes, in place of this, there is a small apparatus, by which a portion of the steam in the chamber *a* is condensed, cooled, and made to flow constantly through a sample jar, in which is a hydrometer, or, what is better, two glass bubbles : one of the specific gravity of 1000 ; the other, 998. The attendant knows all is right when these bubbles, or even the lightest of them, float in the

with the saccharometer, and attach such poise accordingly. Dip the saccharometer into the liquor as far as the bottom

sample; and thus the chamber *a* may be emptied without any risk of loss. When all the wash is gone, a quantity of water is let into the wash charger and sent through the pipes, to finish the process and obtain the last portions of alcohol. The water for supplying the boiler passes through a long coil of pipe immersed in the boiling hot spent wash, by which means it is raised to a high temperature before it reaches the boiler. It will be seen that the vapour passing through this apparatus is all condensed by the wash, not water, the steam and wash acting upon each other as they pass from opposite ends of the apparatus. The consequence of which is, that about three-fourths of the fuel used with the common still is saved. These stills make from 2000 to 3000 gallons of spirits per hour. (See *Ure's Dictionary*.)

Messrs. Blyth and McCulloch have lately patented a "*Double-acted Still*," by means of which a single operation is substituted for the repeated distillation by the old stills, of the wash, feints, low wines, &c., for the purpose of getting rid of the excess of oil. This consists of a wash still and rectifying still combined. The vapour that is generated by applying heat to the wash still passes off through the head and the connecting beak into the main worm, where it is liquified. From the lower end of this worm it falls into a funnel safe, from whence it is conveyed into the compartment separated from the main wash still by a partition and tube; and in this compartment, which is termed the rectifying chamber, it is exposed to the heating effect of the vapour arising from the wash still. The liquid in the chamber is thus volatilised and conveyed by upright tubes to the second beak and worm, flowing from the latter a rectified spirit. The safe through which the low wines, or first product of the wash, flow, is fitted to the circular part of a U-shaped pipe, in which part also there is a two-way cock. The U-pipe being inverted, one leg discharges into the rectifying chamber or still, and the other into the main or wash still. The rectifier is also furnished with an *overflow pipe*, and a *discharge valve*, the overflow pipe being so constructed, that by means of a *ball valve* attached to the lower end of it, any overcharge of the rectifying still will be provided against by the liquid finding a free passage back to the wash still, while, at the same time, no portion of the liquid in the wash still can get into the rectifying one; and by the discharge valve, the contents of the rectifier may at any time be let into the body of the main still; thus giving the distiller an opportunity of modifying his operations as he may desire. There are two worm tubs; one is merely an open vessel, containing the worm connected with the beak of the rectifying still; the other, or main worm tub, is fitted with two worms, one connected with the wash still head or beak, and another through which cold water flows, as circumstances may require. This tub is a close vessel, with the exception of an escapement through a head, similar to that of a still, the purpose of which is to collect and convey to the rectifying still any spirit that may rise as vapour from the surface of the wash; for in this arrangement, the refrigeratory fluid is wash; and when a charge is exhausted, the wash still is replenished from this tub, which is made large enough to hold rather more than a full charge. From condensing the alcoholic vapours passed into the main worm, the temperature of the wash is increased to near the boiling point; and in this state it is kept by passing cold water through the second or regulating worm, until room is made for the charge in the main still by discharging the spent wash.

The *Spirit* produced by distillation is not all of the same strength, that is, it does not always contain the same quantity of alcohol or ardent spirit. It is in fact not possible to obtain alcohol free from water, by simple distillation, on account of the chemical affinity existing between the two bodies; it

of the stem ; then raising it again, return it gently into the sample ; press it about a division lower than the point at

can only be obtained by absorption by means of alkalies. Spirit may be mixed with water in any proportion, and it becomes specifically heavier the more water is added to it. Hence the specific gravity of spirits is a very simple, and at the same time a sure test, for the greater or less strength of alcohol contained in it. *Proof spirit*, is spirit at the standard strength according to which the duty is charged ; and when any spirit is said to be stronger or weaker than this standard, it is understood to be so much per cent. *over proof* or *under proof*. The act of parliament, 58 Geo. III., c. 28, defines proof spirit to be that which at the temperature of 51° weighs exactly $\frac{1}{3}$ parts of distilled water, as indicated by the Hydrometer called Sikes's Hydrometer. Distilled water, which at the temperature of 60° is unity, at the above-named temperature, 51°, is 1·00063, $\frac{1}{3}$ of which is ·9235, which agrees pretty nearly with Sikes's hydrometer, on which proof spirits at 51° are indicated as of the specific gravity of ·9237, and at 60° at ·920. The specific gravity of perfectly pure alcohol is from ·792 to ·800. At the temperature of 60° it is usually stated at ·796, and is then about $\frac{1}{2}$ lighter than water. But by mere distillation the strongest spirit does not yield alcohol of a less specific gravity than ·825. The alcohol of spirits of wine of commerce, and of the London Pharmacopœia, is usually stated at ·835 or ·837, being about 56 per cent. over proof. At 25 per cent. over proof, temperature 60°, the specific gravity is ·8869 ; at 11 per cent. over proof it is ·9061.

Sikes's Hydrometer, by which these strengths are regulated, is made of brass and coated with gold, and its upper stem is graduated on two sides from 1 to 10, and again subdivided into fifths of the larger divisions. It is accompanied by weights, which fit on a stem below the bulb, each of them indicating a proportionate increase which it makes to the instrument. The indications on the instrument have reference to tables with which it is accompanied, and by means of which, in connexion with the temperature (as shown by the thermometer), the strength of the spirit is determined. (See examples in p. 207. See also Table 19 in the Appendix, showing the specific gravity of spirits corresponding with every indication on this Hydrometer.)



SURVEY.

In consequence of the extent and complication of the machinery employed in the manufacture of spirits, the survey is one of great difficulty, and to a certain extent necessarily imperfect. The first thing that an Officer, appointed to survey a distillery, ought to do, is to make himself intimately acquainted with the nature of the different operations, and the character of the utensils and apparatus employed, and in particular should trace the course of every pipe upon the premises and ascertain the exact situation of every cock and outlet.

As one mode of charging the duty is in proportion to the worts or wash made and attenuated, the officer is required by his instructions to be very careful in ascertaining the correct gravity of such worts in its different stages. For preventing imposition upon the Revenue by heavy worts being placed at the bottom of the wash-back, and lighter worts added, he is directed to draw his samples from near the bottom of the vessel, allowing his sinking jar to rest on the bottom before he withdraws the cork. And he is required to preserve samples, not only for ascertaining the true gravity, but also to prevent or detect fraudulent increases made subsequently. He is likewise occasionally to ascertain the gravity of the wash on its removal to

which it is disposed to rest, being careful to avoid disturbing it on removing the finger; observe the linear division

the wash charger, although the fermentation may then have terminated; and he is to observe that the charge must be calculated from the best or highest amount of the wort, wash, or bub, whether in the wort receiver, fermenting back, or wash charger; without any allowance for waste, bub, dregs, yeast, or any matter whatever. The charge arising from the gravity of the worts, although a good check upon the trader, is by no means a true criterion of the quantity of spirits distilled. There are many ways of disguising the true gravity, and even if properly obtained, it frequently falls very far short of the true indication. Mr. Smith, the eminent distiller, in his examination before the Molasses Committee, in 1831, states that in one year he showed produce for 60,000 or 70,000 gallons of spirits more than the quantity indicated by his gravities, and paid duty accordingly; and that, in 1830, he was charged for 80,000 gallons produced beyond such indication. Hence Dr. Ure and others recommend that the officers should use test stills, in order to verify upon a small scale the real quantity of distillable alcohol contained in each back of wash. After the agitation of the wash, three samples should be taken by the sinking jar, one from the bottom, one from the middle, and one from the top; which being mixed and distilled, would denote exactly the whole quantity of spirit that could possibly be extracted. Although this recommendation has not been adopted, supervisors would do well to resort to it, in order that, by comparing the results of their experiments with the spirits brought to charge, they may be able to ascertain whether the operations have been honestly performed. The experiments may be made by a small still, similar to that described in p. 199, or by a common retort and refrigerator, as in p. 189.

Another mode of charge being from the low wines, the officer is required to be particular in ascertaining their quantity and strength; for which purpose he is first to request the trader, or his servant, to rouse and mix the content of each receiver, before he draws his sample, it being probable that the stronger part of the spirit may often lie uppermost; and he is not to allow the samples to be taken, or the sample jars handled, by any one but himself.

The great security of the Revenue, after all, is in the third mode of charge, arising from the quantity and strength of spirits actually produced from the still: hence the necessity of the closest watchfulness at the worm end. The importance of this vigilance cannot be too strongly impressed upon the officer when it is recollected that absence or inattention for ten minutes might cause a loss to the Revenue of hundreds of pounds; and, therefore, any such absence or inattention, if discovered, is properly followed by immediate discharge. The strength of the spirit should be tried immediately after it is run out of the still, and should be repeated as often as possible; and the Officer should be careful to see that no contrivance is resorted to for decreasing the strength in the *safs* by letting in water or otherwise.

As a general rule, the Officer will observe that the per centage required by law to be produced from the worts according to their attenuation is less than the quantity really produced; and, therefore, should the spirits produced be less than such per centage, there will be reason to suspect that fraud has been resorted to, especially if the lower quantity is not limited to a single distillation, and cannot be accounted for by the quality of the malt or otherwise.

To ascertain whether the charge of duty is to be upon the attenuation of the worts.—Multiply the number of gallons of worts or wash by the number of degrees of gravity attenuated (that is, the difference between the highest and lowest gravity of the worts); cut off two figures to the right hand as decimals, divide the product by 5, and the quotient will be the quantity of

nearest to the surface of the liquor at rest; the number of which division, added to the number of the poise employed, is the apparent gravity of the sample. Observe the

proof spirits to be charged; or divide the number of degrees of gravity attenuated by 5, multiply the quotient by the gallons of wort or wash, and the product will be the quantity of proof spirits to be charged; two figures to the right hand being cut off as decimals in addition to the number of decimal places in the multiplicand; as in the following example:—

Suppose the quantity of wash be 4000 gallons, original or highest gravity 65°, and lowest gravity 13°; what is the quantity of proof spirits with which the same would be chargeable?

$$\begin{array}{r} 4000 \text{ gallons} \\ 52 (= 65 - 13) \text{ attenuation} \end{array} \quad \begin{array}{r} 5) 52 (10.4 \\ \hline 4000 \end{array}$$

Or,

5) 2080.00 (416 gallons chargeable 416.000 gallons chargeable.

To ascertain the amount of duty to be charged when such charge arises from the low wines.—Multiply the number of gallons of low wines by the strength per cent. under or over proof (as the case may be); remove the decimal point two places to the left; subtract the product from the number of gallons if the strength be under proof, or add to it if the strength be over proof; the remainder, or sum, as the case may be, will give the quantity of spirits at proof; from which deduct the legal allowance, and the remainder will be the charge; as in the following example:—

Suppose the low wines produced from the wash in the above example be 1063 gallons at 52 per cent. under proof; what quantity of proof spirits will be chargeable in respect thereof?

$1063 \times 52 = 55276$. Then $1063 - 552.76 = 510.24$ galls. proof (p. 44). And $510.24 - 25.51 (= 5 \text{ per cent. allowance}) = 484.73$ galls. at proof, chargeable.

When the strength is under proof, the equivalent quantity of proof is more readily obtained by multiplying the gallons by the difference between the strength and 100, and removing the decimal point two places to the left; thus:— $1063 \times 48 (= 100 - 52) = 510.24 - 25.51 = 484.73$, as above.

To ascertain the quantity and strength to be charged upon the feints and spirits respectively: the equivalent quantity at proof strength must be computed by the methods above described; as in the following example:—

Suppose that from the before-mentioned quantity of low wines and the feints, 54.11 gallons at proof previously remaining on hand, there be produced 439 gallons of feints, at 70° per cent. under proof, and 373 gallons of spirits at 16 per cent. over proof; what quantity of proof spirits would be chargeable in respect thereof?

$439 \times 30 (= 100 - 70) = 131.70$ feints at proof. Then $131.70 + 432.68$ spirits at proof, $(= 373 \times 16 \div 100) = 564.88$. And $564.88 - 54.11$ (feints of redistillation) = 510.27 gallons at proof, to be charged.

From the foregoing examples, it appears that by the first mode of charge, in respect of the wort or wash, the quantity of proof spirits is 416 gallons; by the second mode, in respect of the low wines produced, 484.73 gallons; and by the third mode, in respect of the feints and spirits produced, 510.27 gallons. The quantity of proof spirits chargeable in this instance from the third mode, being the highest in amount, is of course charged.

The maximum or greatest quantity of proof spirits which any quantity of wash is supposed to be capable of producing, must be computed in each case to ascertain whether there be any undue excess in the produce. This is done as follows:—To the quantity of spirits chargeable in respect of the quantity,

temperature by the thermometer—which must remain in the sample for that purpose—and in the proper table accompanying the instrument, under such temperature, will be found the degree of gravity required.*

gravity, and attenuation, of the wash, add its $\frac{1}{2}$ part, and the sum will be the maximum; as in the following example:—

Suppose the quantity of spirits chargeable from wash be 416 gallons, as in the foregoing example, find the maximum quantity: $416 + 83.2 (= \frac{1}{2}) = 499.2$ maximum; which falling short of the highest amount of charge ascertained by either the second or third mode, viz. 510.27 gallons, the difference 11.07 gallons, is deemed an “undue excess,” and a separate account of it is kept, to be charged at the end of the season.

In making out the Annual Balance Account.—To ascertain whether the distiller is chargeable with any duty additional to what has already been charged upon him, the following method may be adopted:—Multiply the quantity of wort or wash made under any notice given for the purpose, by the gravity expressed in such notice; cut off two figures to the right hand as decimals, and divide the product by 5, if it be wort made from malt, corn, or grain, or any mixture thereof, or from potatoes, or from mangel wurzel; or divide such product by 4, if it be wort made from sugar only; and the quotient will be the number of gallons of proof spirits chargeable in respect of such wort or wash. Should the number exceed the number of gallons of proof spirits (exclusive of “undue excesses,”) charged on the distiller during the continuance of his licence, the difference will be the number of gallons deficient, upon which the duty must be charged; as in the following example:—

Suppose that during the continuance of his licence, the distiller had made from grain 316,200 gallons of worts, under a notice to make wort of a gravity of 65 degrees; and 158,100 gallons under a notice to make wort of a gravity of 60 degrees; and from sugar 176,548 gallons, under a notice to make wort of a gravity of 70 degrees; that he had been charged with duty on 91048.18 gallons of spirits; and that the “undue excesses” amounted to 148.88 gallons; what is the balance of his year's work?

$316,200 \times 65 \div 5 = 41,106$	gals. from grain,
$158,100 \times 60 \div 5 = 18,972$	ditto,
$176,548 \times 70 \div 4 = 30,895.90$	from sugar,

90,973.90 gals. proof chargeable from wash,

91,048.18—148.88 = 90,899.30

74.6 gals. deficient, on which duty is charged.

* EXAMPLES OF THE GRAVITY OF WORTS.

(1.) Suppose, on immersing the thermometer, the quicksilver rises to 90° , and on immersing the saccharometer, with the poise 1060, it floats with the line or division 5 nearest to the surface of the liquor; the apparent gravity will be 1065. Refer to Table No. 3, accompanying the instrument, and opposite 1065, under temperature 90° , is 69.3 , the degree of gravity of the worts.

If 1000 be added to the degree found in the table, it will show the specific gravity of the sample, which in the above case is 1069.3, or 1.0693.

For a description of the saccharometer, see p. 198.

If it be necessary to calculate the average declared gravities of different kinds of worts, it may be done as follows:—Multiply the number of gallons by the declared gravity in each case, divide the sum of the products by the

*To ascertain the strength of spirits.**—Pour a sample into the proof glass, and immerse the thermometer, stirring the spirits with it, and waiting till the mercury be stationary; then, without taking out the thermometer, bring the eye to a position exactly opposite the edge or surface of the mercury; note the temperature, and open the Table-book at such temperature. Immerse the hydrometer; press it downwards till the whole divided part of the stem be wet; observe the force required to sink it as a guide in selecting the proper weight, and slip that weight on the bottom of

total number of gallons distilled or decreased, the quotient will be the average gravity: thus,

Gallons Wash.	Declared Gravity.	Product.
110,500	× 60 = . .	6,630,000
11,640	× 57 = . .	663,480
41,580	× 55 = . .	2,286,900

163,720

163,720) 9,580,380 (58·5 average gravity.

See further examples in p. 45.

* EXAMPLES OF THE STRENGTH OF SPIRITS.

(1.) Suppose in 64° of temperature the hydrometer, with the weight 30 on the bottom, sinks to 5 on the stem, the weight of the spirit is 35; then, having found the table for temperature at 64°, look down the columns for 35, opposite to which will be found 31 per cent. over proof. Answer.

(2.) If at the same temperature the hydrometer without a weight sinks to 7 on the stem, the weight becomes 7; then look in the column for 7, opposite to which will be found 60 per cent. over proof.

(3.) If in 50° of temperature the hydrometer, with the weight 70 on the bottom sinks to 2 on the stem; look for 72 in the Table for Temperatures at 50°, opposite to which will be found 18·9 per cent. under proof. Answer.

For a description of the hydrometer, see p. 203.

The lines dividing the columns in the Table, as at 61, show the spirit at that strength to be proof. All strengths preceding these lines are over proof, and all succeeding them are under proof. It is to be observed, that the stem of the hydrometer must not be wet. It is therefore recommended that only so much of the sample as will cover that part be used. Let the hydrometer, the thermometer, the proof-glass, and the samples, remain together for some time previous to their being used, to acquire the same temperature.

The officers are to estimate the temperature by the nearest degree *above* the surface of the mercury when it stands between any two degrees of the thermometer; and the indication by the nearest division *below* the surface of the sample when its level cuts the stem of the hydrometer between one division and another; thus giving the difference in favour of the trader in both cases.

There is a square weight, or cap, which goes on the top stem of the hydrometer, and shows the difference between water and proof spirit, as regulated by the act; and if applied with the weight 60 on the bottom, will sink the hydrometer in distilled water to the proof point, at 51 degrees temperature, indicated on the edge of the stem; the weight 60 alone sinking it

the hydrometer. Again immerse it ; see that the whole be free from air bubbles, and, pressing the instrument down to division 0, let it slowly rise to the resting-point. Bring the eye to the level of the surface of the sample ; note what part of the stem is cut by that surface, *as seen from below*, and add such part or division to the number of the weight, for the indication. Find the indication in the outside column of the Table-book, and upon the same line under the temperature is the given strength per cent. ; those strengths preceding the line of separation being over proof, and those succeeding it, under proof.

To detect the presence of spirits when mixed with sugar,

to the same division in proof spirits at that degree of temperature. It thus appears that the instrument gives the same indication in water with the cap on, as it gives in proof spirits with it off.

The strength is expressed in the Table Book by numbers denoting the excess or deficiency per cent. of proof spirit in any sample ; and the number itself (having its decimal point removed two places to the left) becomes a factor, whereby the gauged content of a cask or vessel of such spirit being multiplied, and the product being added to that gauged content, if overproof, or deducted from it if underproof, the result will be the actual quantity of proof spirit contained in such cask or vessel.

Instead of the Tables a Sliding Rule is sometimes used, and forms a very good substitute. It has been graduated by *Mr. Long*, of Little Tower Street, from the Tables, and is so arranged, that when the temperature is fixed opposite to the index, the strength of the spirit will be found opposite to the hydrometer weight. Thus, in the first of the foregoing examples, if the index, or *fleur-de-lis* be fixed opposite to 64 degrees on the Thermometer scale, then opposite 35 on the slider is 31 overproof on the stock. Again, if the index be set opposite to 50, then opposite to 72, the hydrometer weight (as in Ex. 3) on the slider, will be found 18.9 per cent. under proof on the stock.

It will be observed, that the indication on the hydrometer has no reference to the temperature. This makes a considerable difference in the strength of the spirits, but the difference is regulated by the tables accompanying the instrument, which give the proper strengths under each temperature opposite to the respective indications. The indications are regulated solely by the specific gravity, and may be used for ascertaining the content of the spirit by weight, without regard to the temperature. This is done by means of Long's Table (No. 19, in the Appendix), in which the specific gravity applicable to every indication on the hydrometer is inserted ; and which table is used as follows :—Divide the weight of the spirit in lbs. by the tabular specific gravity found opposite to the indication, and by 10 (the number of lbs. in a gallon) ; the last quotient is the content in gallons. Thus, if it be required to find the content of 588.9 lbs. of spirits, without regard to the strength or temperature ; immerse the hydrometer in a sample of the spirits, and find the indication by the weight and division on the stem, which suppose to be 51.2, refer to Table 19, in which, opposite to 51.2, is .9060, the specific gravity of the spirits ; then say, $588.9 \div .9060 \div 10 = 65$ gallons, content. Again, to find the content of 745 lbs. of spirits, of the hydrometric indication,

*extractive matter, or turpentine**—Distil a sample of the mixture, and find the strength of the product.

40·8, say, $745 \div \cdot 8869$ (Tab. Spec. gr.) $\div 10 = 84$ gallons, content. (See another example in p. 164.)

It thus appears that the tabular specific gravity, with the decimal point removed one place to the right, is the actual weight in lbs. of a gallon of the spirits.

By the Table referred to (No. 19), the specific gravity of spirits of any given strength and temperature may be found as follows:—Find the hydrometric indication of the spirits under the given strength and temperature in the Hydrometer Table Book; then refer to Table 19, and opposite to the indication will be found the specific gravity required. Thus, to find the specific gravity of proof spirits at the temperature of 50°, refer to the Table Book under that temperature, and find the indication for proof, which is 61. Then find the same indication in Table 19, opposite to which is ·9241 the specific gravity required = 9 lbs. 3 oz. 13 drs. per gallon.

* This is a very simple test for ascertaining the per centage of spirits contained in any given mixture. Having ascertained the amount in any given sample, say, as the quantity in the sample is to the quantity produced, so is 100 to the per centage required. The absolute quantity may be found in the same manner, namely, as the quantity in the sample is to the whole quantity, so is the amount produced from that sample to the amount of spirits in the whole quantity. The strength of the spirit in these cases will be the same in the answer as that found in the sample by distillation.

A much readier way of ascertaining the quantity of spirits in mixtures of this description is by means of an instrument called an *Alcoholmeter*, invented by M. Gay-Lussac, and improved under the name of ebulliscope, by M. Brossard-Vidal, and again remodelled by Dr. Ure, under the name of Field's Alcoholometer, under which name it is sold, with the necessary Tables, by Long, of Little Tower Street. This instrument is based upon the fact that the boiling point of a spirituous liquid is scarcely altered by the presence, in moderate quantities, of the substances which may have been dissolved in it, and which, increasing the density of the liquid, render ordinary hydrometers useless for the purpose of indicating its alcoholic richness; or, in other words, that the boiling temperature of alcoholic liquors is, in most cases, proportional to the quantity of alcohol, irrespectively of the quantity of neutro-saline or saccharine matter dissolved in them. It is therefore constructed in such a manner as to show the precise boiling point of any liquid applied to it, and with proper Tables, indicates the exact quantity of sugar or neutral salts that have been mixed with spirits, or used in the composition of beer or cordials. This instrument consists of a flat spirit-lamp, surrounded by a saucer for containing cold water, to keep the lamp cool; of a boiler, which fits by its bottom cage upon the case of the lamp; and there is a damper plate for modifying the flame of the lamp, or extinguishing it when the experiment is complete, and a thermometer, the bottom of the scale of which corresponds to 178·6° Fahr., very nearly, or the boiling point of alcohol at ·920 specific gravity, or proof; and the upper graduations giving the boiling points corresponding to other indicated densities: thus, 179·75° = ·9321 = 10 u. p.; 180·4° = ·9420 = 20 u. p.; 182° = ·9516 = 30 u. p.; 183·40° = ·96 = 40 u. p.; 189° = ·9729 = 60 u. p.; 191·8° = ·9786 = 70 u. p.; 196·4° = ·985 = 80 u. p.; 202° = ·992 = 90 u. p., &c. The manner in which this instrument is used will be understood by the following example:

In taking the specific gravity of a compound, suppose it to be found 1·076. Then take a sample, and, by means of the alcoholmeter, submit it to the

III. SOAP.*

Soap is a chemical compound of oil, fat, or resin with a salifiable base, boiled together in certain proportions in

boiling point, corresponding to which, in the proper Table, will be shown the per centage of alcohol, which suppose to be 35 u. p., the specific gravity of alcohol at that strength will be found to be .956; deduct .956 from the specific gravity of the bulk, or 1.076, and .120 will remain; refer that to its amount in the head-line of the Table accompanying the instrument, under which will be found 3, representing 3 lbs of sugar to the gallon; and in the same column, opposite the alcoholic strength indicated, 35 u. p. will be found 14.9, which represents the per centage of water displaced by the sugar, and which amount of 14.9 added to the 35 per cent. ascertained, makes the total upon the bulk 49.9 per cent. u. p., with 3 lbs. of sugar to the gallon.

The admixture of spirits with *wood naptha*, or of pyroligneous acid, so as to disguise the flavour of the spirit, has been detected by Dr. Ure as follows:—A small quantity of nitric acid, of the specific gravity of 1.45, is first added to the spirits, which, if alcohol is present, immediately produces an effervescence of nitrous ether gas, which may be recognised as such by its odour. The mixture is then treated by a solution of mercury in nitric acid, which is prepared by dissolving 100 grains of mercury in one fluid-ounce of nitric acid, with the aid of heat. Soon after the addition, and especially with the help of a gentle heat, the mixture begins to effervesce, and to evolve thick ethereal vapours. Should the effervescence become too tumultuous or violent, it is quelled by immediately withdrawing the fire, and cooling the vessel. A yellowish grey precipitate falls down, which is fulminate of mercury, and which is immediately separated by decanting or filtering the liquor from it, washing the precipitate on the filter with a little distilled water, and carefully drying it at a heat not exceeding 100°, after which it is weighed. The quantity of fulminate of mercury obtained is nearly equal to that of the alcohol contained in the wood spirit, and at any rate the formation of the detonating salt is quite characteristic of the presence of alcohol, since wood spirit treated by nitric acid and mercury, or silver, can produce no fulminate of silver or of mercury. This is, however, a dangerous experiment for a person not accustomed to chemical manipulation. For distinguishing wood naptha from alcohol, and ascertaining whether the former is genuine, or illegally mixed with alcohol, without experiment, Dr. Ure recommends the use of caustic potash, in powder; for if wood spirit is present, the liquor then assumes a brown colour, whilst pulverised potash does not alter the colour of pure alcohol, even after several hours; and it is only after a whole day's contact that a feeble yellowish tinge is developed. On the other hand, if the alcohol contains only two per cent., or even one per cent. of wood spirit, it turns yellowish in the course of ten minutes, and brown in half an hour. It appears, also, that the boiling point of wood naptha spirit is at least 20° below that of alcohol of the same gravity, and it exhales the characteristic pungent and offensive odour of aldehyde.

* The term *Soap* originally meant the compounds derived from the union between fatty bodies and the alkalies, potash, and soda; and although it is still usually thus limited in its meaning, it has nevertheless been extended to compounds of oleaginous bodies with some earthy and metallic bodies,

a copper. The result of this treatment is the well-known detergent, which is called *hard soap*, or *soft soap*, according to the materials employed; the former being produced by the action of soda, the latter by that of potash. After hard soap is formed it is emptied into wooden or iron frames, where it is cooled, and afterwards cut up into slabs or bars for consumption. If silica or clay be used in making hard

having but few properties in common with soap properly so called. Hard soap is usually made in this country by mixing tallow or some other oily acid with an aqueous solution of caustic soda, that is, of carbonate of soda deprived of its carbonic acid by means of lime, and boiling the mixture in an iron pan or copper. When combination has taken place, or, in other words, when the soap is formed, a quantity of common salt is added, which, dissolving in the lees, increases their density, and the soap then floats on the surface of the liquid; the fire being then extinguished, the semifluid soap, after a proper interval, but while yet hot, is removed from the lees and put into frames of wood or iron, where it remains until it has become cool and hard, when it is cut into bars for sale. Of late years palm oil, or cocoa-nut oil, has been used, partly or entirely to supply the place of tallow: the palm oil, because it is cheaper than tallow; and the cocoa-nut oil, because it communicates to the soap the property of forming a strong lather. The principal kinds of hard soap manufactured in England are *white* or *curd soap*, made chiefly from tallow and soda, but, for some particular purposes, olive oil and soda; *yellow soap*, composed of tallow, resin, and soda, to which palm oil is occasionally added; and *mottled soap*, made from tallow, kitchen stuff, and soda; the mottled appearance is given to this soap by dispersing the lees through it towards the end of the operation. There is also a *brown soap*, made from palm oil and resin. This oil contains palmitic acid. *Silica soap* contains a portion of calcined flints reduced to a fine powder; and *clay soap* contains a portion of white clay made into a thin paste with water; the silica or clay, as the case may be, being either mixed with other materials in the pan, or "crutched" in the frames. *Soft soap* is generally prepared from fish oil and potash. Linseed oil, cocoa-nut oil, and whale oil are also occasionally used; and formerly barilla, an impure carbonate of soda, prepared chiefly in Spain, was employed in England; while *kelp*, or incinerated sea-weed was, and still is, to a certain extent, used in Scotland. The materials are boiled in a copper, like hard soap; but, after a sufficient evaporation of the water, they yield a soft mass, which is emptied from the copper into barrels for sale, without being cooled or hardened in frames. This kind of soap is frequently employed in printworks for cleansing coloured fabrics.

It thus appears that hard soaps are formed from fats by soda; soft soaps from potash. The chemical process taking place in both cases may be explained as follows:—Oils and fats consist chiefly of three principles of different consistency, the one more fluid than the two others. The first is called *oleine*, and is always liquid at the ordinary temperature; the two others are called *stearine* and *margarine*. These substances, chemically considered, are really salts; and when they are treated by a solution of potash or soda, their constituents react upon each other, and combine with the potash or soda, to form the neutral compound, soap.

The chief object of the Officer's survey on hard soap is, to ascertain that all the soap is duly conveyed out of the copper into the frames, and then to obtain the earliest and most correct account of the quantity cleansed. For

soap, the duty is assessed according to a standard different from that adopted when ordinary materials are employed.

To ascertain whether soap contains silicious or earthy matter.—Prepare a liquor consisting of water and common table salt, in which a glass bead of the proper weight will neither float on the surface nor sink to the bottom, but rest in any part in which it may be placed; drop a bit of the

this purpose he is required frequently to examine the state of the materials or soap in the copper or frames; to compare the same with the state of such materials or soap as found on former surveys; to see that the coppers are carefully locked, and secured with proper labels, when not open under regular notice; frequently to examine the state of the copper coverings and fastenings; always to be present, if possible, when the soap is cleansed out of the copper into the frames; and immediately, or as soon afterwards as possible, to gauge the soap in the frames; and to continue to gauge it on every survey afterwards, until it is entirely cut up and removed; carefully entering an account of his surveys and gauges in his survey book.

At large establishments, and when a trader works in the night, or keeps his soap an unusual time in operation, an assistant is employed, and his duty is to remain on the premises (in conjunction with the surveying officer) all the time that any copper is open for working. It is unnecessary to say that, as so much depends upon the strictness with which this watch is kept, absence from his post, on the part of the Officer, is always followed by immediate discharge.

The duty on silitated soap and clay soap is in effect higher than that on common soap, 24·04 cubic inches being charged as 1 lb. when hot, instead of 28 inches, the allowance for hot common soap; it is therefore important to be able to distinguish readily the one kind from the other. The criterion established by the act is the specific gravity, which, if it be found to be greater than 1·05 within 48 hours after the soap is cut up, is to be deemed conclusive evidence of its being silitated. To enable the Officers to determine whether soap exceeds this specific gravity, the Board furnishes them with a number of glass beads of the specific gravity of 1·05; and the directions in the text for testing the soap by means of these beads are very simple and perfect. As the experiment requires little trouble in performing, the Officer should never neglect to make it on all proper occasions; and in every case in which the specific gravity is exceeded, the samples should be preserved and the circumstances stated to the Board.

The specific gravity at which hard soap is allowed to be exported on drawback, is not to exceed 1·22; and the Officers who attend the packing of such soap are furnished with glass beads to test the specific gravity thereof, in the same way as in the case of soap at the manufactory; but in making up the gravity of the liquor required for this purpose, the Officer is directed to add to it, as much common salt, as it will dissolve; and if the beads should then sink to the bottom, to add sugar by little and little, shaking the mixture well till the beads neither sink to the bottom, nor float on the surface; and if on then dropping into the liquor a bit of the soap, it sinks to the bottom, it is considered to be of a greater specific gravity than is allowed to be exported, and if produced to the Officer for that purpose, must be seized.

Another mode of testing the presence of clay, chalk, silica, dextrine, fecula, pumice-stone, ochre, plaster, salt, gelatine, &c., is to dissolve 1000 grains of the suspected soap in alcohol; with the help of a gentle heat the alcohol will

soap of about the size of a nut into a glass-full of the liquor : if the soap sink to the bottom and remain there, it is an indication that it contains silicious or earthy matter.

IV. PAPER.*

Paper is made from rags and other fibrous materials, which are cut and bruised in water till they are separated into fine and short filaments, and become a sort of pulp. This pulp after being bleached by a chemical process is taken up in a thin and even layer upon a mould, which allows the

dissolve the soap, and leave all these impurities in an insoluble state. Good mottled soap should not leave more than one per cent. of insoluble matter, and white or yellow soap less still. All soap, to which earthy or silicious matter has been added, is opaque, instead of being transparent, on the edges, as is the case with all genuine fitted soap. The drier the soap, the more transparent it is. If silica has been added in the state of silicate of soda or of potash, it is necessary to proceed as follows : a given weight of the suspected soap should be first dissolved in a suitable quantity of boiling water, and decomposed by the gradual addition of moderately diluted hydrochloric acid. The fatty acids which separate, being removed, the acid liquor should be evaporated to dryness ; the dry mass, being treated with boiling water, will leave an insoluble residuum, and may be identified as silica by its grittiness, which is recognised by rubbing it in the capsule with a glass rod. This residuum of silica is then collected on a filter, washed, dried, ignited, and weighed. (See *Normandy's Commercial Hand-Book*.)

* The chief article used in the manufacture of paper is rags, a considerable portion of which is imported from foreign countries. In making paper, the first business is to sort the rags and cut them into small pieces. This is done by women, who, after separating the threads and seams, throw the pieces into five or six different compartments according to their qualities. The finest linen rags are used for the best writing paper, but cotton as well as linen rags are now used for printing paper. Hempen rags are used for coarse paper, and old cordage, tarred ropes, and even straw for brown wrapping papers. The rags are then dusted if necessary, and washed with hot water in a fulling mill or subjected for some hours to the action of steam, ingredients being sometimes added for the purpose of bleaching. The rags are then placed in the *engine*, or as it is termed by the workmen, the breaking-in-machine. This powerful apparatus, which is frequently worked by means of a water-mill, consists of an elliptical shaped trough made generally of wood lined with lead or copper ; within it a grooved roller revolves horizontally over the surface of a sharply grooved plate, by which the rags are torn to shreds ; the grooves on the roller and those on the plate acting upon the pieces of rags much in the same manner as cutting with a pair of scissors. This operation, which is called "grinding," reduces the rags to a pulp ; the machinery being so contrived that water may pass in and out to aid in the working and cleansing without carrying off the materials. During or subsequent to this process the pulp is subject to the application of chloride of lime, or of chlorine gas, for the purpose

water to drain off, but retains the fibrous matter, the filaments of which, are, by the process of the reduction to pulp and subsequent drying and pressing, so interwoven or felted together that they cannot be separated without tearing, and thus form paper. When the paper is made and cut into

of *bleaching*, and it is afterwards again put into a washing machine to free it thoroughly from the bleaching liquor; it is then passed into the *stuff-chest*, from whence it is taken as it is wanted, into a vat and mixed with a sufficient quantity of water and kept in a lukewarm state, ready for the mould. Paper is made either by *hand*, or by machinery. For the former process, moulds of the size of the paper intended to be made, with bottoms of iron or brass wire, something like a sieve, are dipped into the vat, and the pulp in a fluid state is taken up and gently shaken by the workmen, so as to leave the pulp when the water is drained off, equally spread over the surface of the wire. It is then gently turned upon a woollen cloth called a *felt*, and thus becomes a sheet of paper. On this sheet another felt is laid, and another sheet upon that, and so on alternately till a heap is raised, called a *post*. The whole is then put into a press, and after the water is squeezed out the sheets are separated from the felts, and laid one upon another and again pressed and afterwards hung in parcels called *spurs*, of three, four or five sheets in each parcel, upon lines called *trebles* in the drying-houses. The paper is next counted into quires, and after it has been pressed, is tied up in reams, half reams, or parcels, and enclosed in the required wrappers for being weighed and charged with duty. Brown, whited-brown, and other coarse papers, not requiring to be sized, are sooner dried and finished. When paper is made by *machinery*, which is now the most common method, the pulp is discharged or run from the vat upon a brass wire web revolving upon cylinders, by which the paper can be made of almost any length. As it is made it is passed between hot iron cylinders to dry, and wound off upon a reel, placed at the lower end of the machine, and moving in nice accordance with the machine, as the web of paper is formed and moves onward; and when the reel is sufficiently full, the paper is cut upon it into sheets of the size required. Sometimes the whole process is performed by different parts of the same machine. Mill-board (except when it is very thick), button-board, button-paper, glazed paper, and sheathing-paper, are made after the same manner, differing however, in the sheets being made thicker, either by repeated dips in the vats, or by laying two or more sheets, one upon another, on their being turned out of the mould, and pressing them together whilst in a wet state; and in putting up, the sheets are not folded, but spread, and severally tied up in parcels of even dozens. Very thick mill-board is made in a frame with a press to it, the pulp being taken out in a hand-bowl, and spread to the required thickness in the frame, when the press is applied to squeeze out the water, and the sheet is formed.

As the duty on paper is charged by actual weight, the business of the Officer is to ascertain that the whole of the paper made is brought to the scale to be weighed and charged. For this purpose, he ought upon his surveys to be careful in examining the places, where it is probable any paper may be concealed; and to note the extent of the trader's operations so as to be able to estimate, whether more be made than is accounted for. His attention ought also to be especially directed to the wrappers and labels, so as to ascertain that they are not used a second time, it being a common practice with fraudulent paper-makers, to have the labels privately returned from their customers for this purpose. Sometimes also the wrappers are opened after the

proper lengths it is tied up in wrappers and labelled with a government stamp, indicating that it has been charged with the excise duty.

V. SUGAR.*

Sugar is a sweet granulated substance, everywhere in extensive use, and ranking in this country among the necessities of life. It is made chiefly from the sugar cane, which is raised in America, and the West Indies, whence it is imported usually in a rough state, and afterwards refined in this country. The manufacture of sugar from potatoes, has recently been attempted in England on a very limited scale by a chemical process described in the note; and it is upon the sugar so manufactured that the present excise duty is imposed.

Officer has tied them up and labelled them, and after new or additional paper has been put in, alterations of the weight are made upon the labels, by erasing the official marks or effacing them by a chemical process and substituting others. Sometimes also paper is sent away privately, without wrappers or labels. The detection of these frauds, requires the vigilant attention of the Officer.

* In England the manufacture of sugar is very limited. The material chiefly employed here is potato starch, which is mixed with water at a proper temperature in a mash tun, and then removed to a decomposing vat, in which it is boiled with sulphuric acid. After boiling between six and eight hours, it is run into saturating vats, where, by means of chalk, the acid is absorbed, which is generally effected in about eight or twelve hours; it is then purified by being passed through filters of charcoal, from which it is discharged into the juice-cistern, where the first account is taken by the Officer of the quantity and gravity. The juice is then removed to the evaporating pans, and thence a second time into the filterers, from which it is discharged into the syrup cistern; and then again removed to the evaporating pans, into which it is reduced by evaporation to the required consistency. It is then removed by pipes into the concreting pans, and there remains until it is crystallised, which is sometimes effected in five or six days, and, at other times, requires as many weeks. The sugar is now perfectly formed, and only requires to be dried, which is done by exposure to the sun in large trays in summer, and by being placed in a heated room in winter. It is then ground and sifted; afterwards it is produced to the Officer to be weighed, which forms the second mode of charge.

Should the manufacture of sugar in this country be extended, it will be necessary that the Officers appointed to survey it should become acquainted with the process, and especially with the mode of obtaining the specific gravity of the syrup.

VI. HOPS.*

The *Hop* is a slender climbing plant of the genus *humulus*, that creeps up a pole or any other support in a spiral form, ascending always from the right hand to the left. It is extensively cultivated for the flowers or seed-vessels, which give flavour and permanence to beer by being boiled with wort in brewing. The flowers are gathered and cured under the survey of the excise officers.

* Hops impart a pleasant, bitter, aromatic flavour to beer, and prevent the too rapid progress of fermentation. Beer which is well hopped will keep well, and become very fine without any of those artificial means of fining which make other beer so much inferior in quality. The most extensive English plantations of hops are in Kent, Sussex, and Herefordshire; but they are also cultivated in Worcestershire, Wiltshire, Hampshire, Gloucestershire, Surrey, and several other counties. Hops begin to blossom about July, and are fit to gather about the end of August or beginning of September. Great numbers of men and women are then employed for "picking," which is to be done as quickly as possible, and before they are ripe enough to shed their seeds. In the picking, the poles are taken down, the stems are cut three feet from the ground, and the flowers are detached and put into large rectangular frames, called bins, and sorted. They are then taken to an oust or kiln, to be dried or stoved; they are afterwards laid in heaps on the floor, where they undergo a very slight heating. As soon as this is observed they are bagged. This is done through a round hole made in the floor of the loft where the hops are laid. Under this hole is a bag, the mouth of which is drawn through the hole and kept open by a hoop, to which it is made fast. As the hops are thrown into the bag, they are trodden down with the feet, and afterwards should be subjected to the action of a hydraulic press. The packing of the hops is one of the most important operations towards their preservation, and is probably the cause of the enormous difference in value between the English and French hops after a few years' keeping. By the English method the valuable yellow powder which gives the characteristic taste to the beer is inclosed on every side by innumerable compact scales, and completely screened from the contact of the atmosphere, and from all its vicissitudes of humidity; and its essential oil, in particular, the basis of its flavour, is preserved without decay. The best hops have a golden yellow colour, large cones, and agreeable aroma; when rubbed between the hands they leave yellow traces, powerfully odoriferous, without any broken portions of the plant, such as leaves, stems, and scaly fragments. When alcohol is digested in good hops, from 9 to 12 per cent. of soluble yellow matter may be obtained by evaporating it to dryness. This is a good test of their quality. The best flavoured and palest hops are packed in sacks of fine canvas, which are called *pockets*, and weigh about 1½ cwt. each. These are bought by the ale brewers. The stronger flavoured and darker coloured hops are packed in bags of a very coarse texture like door-mats, called *hop-bags*. These contain generally about 3 cwt., and are sold to the porter and beer brewers. The hops are weighed by the Officer in the pockets or bags, on which the weight is marked.

As the duty is charged by weight, the business of the Officers appointed to

VII. BEER.*

Beer is fermented malt liquor made by the process of brewing, which consists of the six following stages, namely,

survey hop-planters is to see that all the hops grown and cured are brought to the scale to be weighed; and his previous surveys and entries have all reference to this point. The officer should be careful to prevent the hops from being secretly removed before they are charged, and also that none are put into bags which have been used before, as this fraud is sometimes practised, and the duty thereby evaded. He should also ascertain that the scales and weights used are correct, the best test for which is to change the weights from one scale to the other.

* Brewing is a chemical process for extracting a saccharine solution from grain, and converting that solution into a fermented and sound spirituous beverage called *beer* or *ale*. The grain used for this purpose in the United Kingdom is malt, the use of all other kinds being prohibited. The first step in the process of brewing is the *grinding* of the malt, which is done by the common arrangement of millstones, or by an adjustment of cylindrical iron rollers. After this it is subjected to the process of *mashing*, the ground malt being placed in a mash-tun with a false bottom, and hot water admitted either above or between the true and false bottom, so that the grist is intimately mixed with the water. The infusion or sweet wort is then allowed to run off into a vessel called the under-back, from whence it is pumped, or otherwise conveyed into a copper for *boiling*. When the whole of the worts are pumped into the copper, the hops are thrown in, and the boiling commences. When the boiling is complete, the whole contents are turned into the hop-back or jack-back, from which the boiled worts drained from the hops are then allowed to run into a number of shallow tubs called *coolers*. In these vessels it remains exposed to a free current of air until the liquor is reduced to a proper temperature, which for ale is from 70° to 80°. The next operation—that of *fermentation*—is carried on in a guile, or fermenting-tun, in which yeast is added to the worts, and fermentation takes place similar to that described under the head “Spirits.” When it has arrived at a certain point of attenuation, that is, when a certain quantity of the saccharine matter of the wort has been converted into alcohol, it is *cleansed* from the yeast; and for this purpose it is either run into smaller vessels, such as casks or rounds, or the yeasty head is skimmed off from the top; and this is repeated until the beer is cleansed. It is then either *racked* directly into casks as for ale, or run into vats prepared for it.

There being no duty on beer at present, the survey of the officers at breweries is very partial, and intended only as a check upon the quantity of malt used or beer brewed in a year, from which to calculate the amount of license duty, which depends upon such quantities. There is an exception, however, to this limitation, in case the brewer uses sugar under the recent regulations; in which case, being chargeable with an Excise duty on the sugar used, the officer's survey is necessarily more particular, as a check upon the quantity used.

With the exception last referred to, as to the use of sugar under certain restrictions, the brewer is prohibited, under heavy penalties, from mixing with his beer, either in the process of brewing or afterwards, any molasses, honey, liquorice, vitriol, quassia, cocculus Indicus, grains of Paradise, Guinea pepper, or opium, or any extract or preparation of such articles, or any

grinding, mashing, boiling, cooling, fermenting, and cleansing. Beer, with a very limited exception, is required by law to

article or preparation whatever, for, or as a substitute for, malt or hops. Publicans and beer-sellers are also subjected to the same restrictions; the object of which is to protect the duty on the malt and hops. When any of these adulterating ingredients are used by the brewer, they are usually boiled with the worts; and it is afterwards difficult to detect their presence in the beer, or at least to substantiate their introduction without corroborative evidence. If an officer, therefore, suspects any brewer to be in the habit of resorting to these frauds, he should take every opportunity of watching the premises, in order, if possible, to detect the workmen introducing the adulterating articles, or to find them concealed on the premises. The officer should also make himself acquainted with the character and appearance of the different articles used for adulteration, after they have undergone the process of boiling, in order that he may be able to distinguish them, should he at any time discover them in the spent hops, which for this purpose he should take every opportunity of examining. Grains of Paradise, on being boiled, become black; whilst the hop seed, which it resembles, is found of a light brown colour. Capsicum, cocculus Indicus, or quassia, will be known by their taste. Should any suspicious article be discovered, it should be seized, and a portion of it examined, and, if necessary, sent up to the Board for analysis. Beer retailers are in the habit of adulterating their beer with a mixture composed of caramel, or burnt sugar, treacle, liquorice, spruce, and copperas, or the sulphate of iron, by which they are enabled to add 50 per cent. of water to their beer. Mr. Scott recently detected many of these frauds by unexpected visits. The following tests for detecting the presence of adulterating articles in beer are taken chiefly from *Normandy's Commercial Hand Book*.—

To ascertain whether beer contains common salt.—Put into a sample of the suspected beer a solution of nitrate of silver, which will produce a precipitate insoluble in water and in nitric acid. This precipitate may be washed, dried, fused in a small porcelain crucible and weighed. 134 grains of chloride of silver represent 60 grains of common salt.

To detect the presence of sulphate of iron or green copperas.—Take a sample of the suspected beer, and decolourize it as much as possible by animal charcoal; let it be filtered, and test the filtrate by hydro-sulphuret of ammonia, which, if the salt be present, will produce a black precipitate. If tested by ferricyanide of potassium there will be a blue precipitate. If a solution of chloride of barium be added to another portion of the filtrate a white precipitate of sulphate of baryta will be produced, which may be filtered, washed, dried, ignited, and weighed. 117 grains of sulphate of baryta represent 139 grains of crystallized proto-sulphate of iron.

To detect the presence of opium.—The suspected beer is first to be decolourized as much as possible by animal charcoal; a portion of the filtrate is then poured into a conical glass, and a few drops of acetate of lead are poured in. In the course of about 12 hours, or sooner, a precipitate, which is a meconate of lead, will be produced, especially by stirring the whole from time to time. The precipitate which will have collected at the bottom of the test glass is then separated from the supernatant liquor by careful decantation, and 30 or 40 drops of sulphuric acid, and a like quantity of protosulphate of iron, are then placed on the meconate of lead at the bottom of the test glass. By this treatment the meconate of lead is decomposed and converted into sulphate of lead; whilst the liberated meconate acid, reacting upon the protosulphate of iron, produces a beautiful red colour.

To detect the presence of carbonate of soda.—Let a portion of the

be made of malt, hops and water only, and the chief object of the present survey upon brewers and beer-dealers, is to prevent the introduction into the beer of other articles.*

VIII. TOBACCO.†

Tobacco is imported into this country in the leaf, and it is here manufactured into a proper state for consumption, as

suspected beer be evaporated to a syrupy consistence, and stirred with a small quantity of weak alcohol, in order to dissolve the acetate of soda. On evaporating, acetate of soda will be obtained in crystals, which, heated before the blow-pipe, will impart a deep yellow tinge to the flame, and which, when treated with concentrated sulphuric acid, will evolve pungent vapours of acetic acid.

* As a farther protection of the malt duty, brewers are prohibited from having unmalted grain on their premises. For the mode of distinguishing malted from unmalted grain, see p. 192.

† Tobacco is the well-known plant belonging to the monopetalous genus, *nicotiana*. It is cultivated chiefly in America and the West Indies, and imported from thence usually, in the state of dried leaf, packed in hogsheds, in which it is compressed by a powerful lever press. In this country the tobacco leaves are manufactured into the numerous varieties of *tobacco* for smoking in pipes, consisting of the leaf, cut up into shreds or filaments, and sometimes divested of the stock; into *cigars*, which are bundles of the tobacco leaf, divested of their stalks, rolled compactly together into a convenient form for smoking; into *roll-tobacco*, in which the leaves are twisted like a rope, for chewing; and into *snuff*, which consists partly of the stalks of the leaves and partly of the leaves themselves, cut and ground into the state of powder. The manufacture of tobacco, properly so called, is performed as follows:—After separating all the damaged leaves, the tobacco is spread in a heap upon a stone pavement, each layer, in succession, being watered, till a ton or more be laid; the principles of the tobacco are then left to react on each other for three or four days, according to the temperature and nature of the tobacco. The fermented leaves being next stripped of their middle ribs by the hands of children, are sorted anew, and the large ones set apart for making cigars. If, however, the stalks remain, they are used for the production of a kind of tobacco called “bird’s eye.” To prepare the leaves for being cut into shreds or filaments, they are pressed together in large numbers in the form of a cake; during which operation, which is called “boxing,” they are again occasionally moistened, and after being subjected to a heavy pressure in a “mortar press” and “standing press,” they are removed to the “cutting engine,” in which they are cut into shreds, if for “shag” tobacco, or very small, if for “short cut” tobacco; it is then ready for consumption. “Cigars” are made up by the hand after the leaf has undergone a process something similar to the above; and “snuff” is made in the same way as tobacco, except that greater care is employed, and some essential oils are allowed to be used in the manufacture. Except in snuff and roll tobacco, the manufacturers are prohibited from mixing with their tobacco, either in the process of manufacture or at any other time, any commodity but water. They are also restricted from having in their manufactories any comings or roots of malt, or any ground or unground roasted grain,

shag tobacco, roll tobacco, cigars, or snuff. There is a heavy Customs duty, payable on the importation of the leaf, and

ground or unground chicory, lime, sand (not being tobacco sand), umbre, ochre, or other earths, sea-weed, ground or powdered wood, moss, or weeds, or any herbs or plants (not being tobacco leaves or plants), or any substance or material, syrup, liquid, or preparation, matter, or thing to be used, or capable of being used as a substitute for, or to increase the weight of tobacco or snuff. Dealers and retailers are also prohibited from mixing adulterating ingredients with tobacco; and all persons are forbidden to colour or stain leaves of plants in imitation of tobacco.

The foregoing list will serve to indicate the nature of the adulterations, which it is the great object of the Excise survey to prevent, in order to protect the heavy duty charged on the article on importation; and it may be observed here, as was done with regard to beer, that the most effectual mode of detecting frauds of this description is, to set a watch upon the parties who are suspected, and discover them in the act of concealing or using the adulterated articles. In this case, also, the officer should make himself familiar with the different materials referred to in the above list, or any other that are likely to be used, so that he may know them if he should find them on the trader's premises, or mixed with the manufactured tobacco.

Next to the actual detection of the adulteration on the premises, the most effectual means of ascertaining the presence of any adulterated article in manufactured tobacco or snuff, is a powerful microscope; and even one of limited powers is frequently sufficient to show the difference between the component parts of the genuine article and those of the adulteration. For instance, if a portion of the tobacco called bird's-eye, which constitutes a great part of the tobacco now made, be submitted to the microscope, or a magnifying glass, it will exhibit in the cuttings of the stem, a small figure like a "horse-shoe," which differs altogether in appearance from the cuttings of any other plant. Experience will further enable the officer to distinguish the characteristics of the genuine plant from those of any other.

For detecting the presence of sugar, molasses, honey, liquorice, or other saccharine matter, the rule in the text, taken from the Board's order of 4th December, 1844, will be found very useful, as will also the following directions, from the same paper:—

“The Board having reason to believe that many manufacturers of tobacco are still in the practice of adulterating their tobacco by adding thereto, in the process of manufacture, saccharine matter, such as sugar, molasses, liquorice, &c., also woody fibre, or the leaves of trees and plants other than tobacco; and sometimes earth and salt: it is ordered that the officers of the Revenue use every means in their power to prevent these practices.

“It is to be observed that the articles herein mentioned are generally introduced at the time of liquoring the tobacco, and immediately before it is boxed up for the process; visits must, therefore, be made at such times, when by opening out the leaves of tobacco and closely examining them, any adulterating matter adhering thereto will be readily detected. Frequent and unexpected visits should also be made, sometimes early in the morning, and sometimes late in the evening; and, under circumstances of sufficient suspicion, between the hours of ten at night and six in the morning (as between these hours, officers can legally enter, in the presence of a constable or peace officer), and upon every visit the officer must examine carefully and satisfy himself not only that the tobacco in operation is pure, but that there is not on the premises any description of saccharine matter, preparation of starch, or any other article, which, under the penalty of £200, tobacco manufacturers are prohibited from having on their premises.

the British manufacturers are placed under the survey of the Excise officers, in order to prevent the introduction of smuggled tobacco, and the admixture of articles which have not been charged with duty.

To ascertain whether manufactured tobacco has been adulterated with sugar, molasses, honey, liquorice, or other saccharine matter.—Take about an ounce of the suspected tobacco, and pour over it in a basin rather more than a quarter of a pint of water, at 110° temperature; press out the soluble portion of the tobacco with the hand; then place two glass tumblers or tea-cups in a basin of water at about 98° temperature; into one of them pour the tobacco infusion, and into the other a like quantity of water of the same

"After the tobacco has been manufactured, adulterating matter can be detected by chemical analysis; but those officers who have not the means or the skill to make such trials, will find that sugar, molasses, honey, liquorice, or any other kind of saccharine matter, produces a bland soft flavour in the mouth, by breaking down the acrid bitter principle of the plant; common salt produces a softness, which may be easily detected by its flavour; nitrate of potash, or saltpetre, produces a coolness on the palate; sulphate of magnesia, or Epsom salts, and sulphate of soda, or Glauber salts, a cool bitter taste, softening considerably the acrid principle of the tobacco.

"When, from the taste or otherwise, the presence of saccharine matter is suspected, the fact may be ascertained by fermentation in half an hour." [Then follow the directions in the text.]

"The Board expect that their officers will avail themselves of every opportunity to acquire a knowledge of tobacco, and to test frequently its purity; more especially the tobacco of such manufacturers as are known to sell under a fair market price; and that, when they shall have good reason to suspect that any tobacco is adulterated, they transmit samples thereof hither, as directed by General Order of 29th April, 1843."

Mr. Phillips' method of discovering adulteration in tobacco, as communicated by me to the British Association at York, in 1844, is as follows:—The basis of the plan is the ascertainment and comparison of the relative proportions of soluble and insoluble matter in tobacco, water being the solvent. Numerous experiments have proved that every kind of vegetable matter has a determinate portion, which is soluble in water; thus rhubarb leaves range from 18 to 26 per cent., and horse-radish, lettuce, oak, elm, and many others, have their definite limits. This amount, with reference to tobacco, in no case exceeds 55 per cent. of the tobacco; and thus if tobacco be adulterated with matter soluble in water, the extractive, or soluble part is increased, whilst the ligneous and insoluble matter are correspondingly decreased. A sample of genuine tobacco, by careful manipulation, affords 50 per cent. of soluble matter, and when another portion of the same tobacco has been mixed with 15 per cent. of soluble matter, the sophisticated article can contain only 85 per cent. of tobacco; and it will be found by experiment to afford to water 57·6 of soluble, and 42·5 of insoluble matter; thus affording proportions for calculating the actual amount of adulteration introduced. See *Report*, p. 29.

temperature ; add a teaspoonful of fresh yeast to each, and stir the contents, keeping up the temperature of the water in the basin and observing the results. If the tobacco contain saccharine matter, a brisk fermentation will immediately commence, and bubbles of carbonic acid gas will be liberated, forming a frothy head ; whilst in the other tumbler or cup, containing yeast and water, a very slight fermentation only will take place. If the tobacco infusion present the same languid appearance as the yeast and water, there is no indication of the presence of saccharine matter.

IX. TEA, COFFEE, COCOA AND PEPPER.*

Tea, coffee, cocoa and pepper, are imported from foreign countries, and are subject, on importation to the united king-

* TEA.

Tea, the well-known Chinese plant, genus *thea*, is so extensively used in this country as to be classed among the necessities of life. It is imported from China in vast quantities, and is supposed, in many instances, to be extensively adulterated before it is sold into consumption.

To ascertain whether other than tea leaves have been substituted for, or mixed with, genuine tea.—To do this effectually it is necessary to acquire a thorough acquaintance with the character and appearance of the tea-leaf, and also of the leaves which are sometimes mixed with tea, in the various stages of their growth, especially the condition of the edges, and the arrangement and distribution of the bundles of woody fibre and vessels called veins. An idea of the general appearance of the tea-leaf, and of the leaf of the poplar, elder, sloe, and oak, may be formed from the following diagram :—



It will be seen that the tea-leaves have a different structure from the sloe and elder, which are most commonly substituted for them. They are more elongated and more delicately serrated. Before examination the leaves should be untwisted by infusion or moisture. They should then be submitted to the microscope, by which the tea will, in most instances, be distinguishable from the substitute, even if the latter be ground or rubbed into very small pieces. Another mode of distinguishing tea-leaves from others, is by infusing a

dom, to duties of Customs at different rates. Tea in particular produces a considerable amount of revenue. The

portion of each. Genuine tea contains gum, gluten or saccharine matter, a large quantity of *tannin*, and a peculiar nitrogenized principle called *theine*, which are quite distinguishable from the component parts of other leaves. The leaves of the sloe are astringent, and contain a considerable quantity of tannin, and on this account they are frequently employed in adulterations. On analysis it is found that while the average amount of nitrogen or *theine* in tea exceeds 5 per cent., that in sloe, hawthorn, and elder leaves but seldom exceeds 3 per cent., and in the first two is always much under this average.

To ascertain whether tea has been dyed or mixed with adulterating ingredients.—The presence of *Salt of Copper*, may be detected by putting a pint of tea into a flask with a small quantity of cold water, agitating it or shaking it for some time and throwing the whole upon a filter; a portion of the liquid which filters through, being tested with ammonia, will, if adulterated, immediately assume a beautiful sapphire blue colour; another portion of the filtrate, being tested with ferrocyanide, will produce a reddish brown precipitate of ferrocyanide of copper. The presence of *Logwood* may be detected by moistening a small portion of tea leaves, and rubbing them gently on a sheet of white paper, which in that case will be stained bluish black. If a portion of the tea be thrown into cold water, it immediately imparts a pinkish or purplish colour, which becomes red by the addition of a few drops of sulphuric acid. This is an indication of the presence of logwood, for genuine black tea produces only after a time a golden brown liquor, which is not reddened by sulphuric acid. The presence of *Plumbago* or *Black lead* is detected by the shining or lustrous appearance of the leaves. If a thin slice be removed from the surface of one of the leaves and placed under the microscope, it will be seen to be minutely studded with numerous small black particles. And if a spoonful or two of the tea be infused in boiling water, the liquid will frequently acquire a blackish hue, and on evaporation the bottom of the vessel will be found to exhibit the dark shining and characteristic coating of black lead. The presence of *Talc*, *China clay*, and *Soap stone*, is indicated by the silvery lustre of some of the particles when placed under the microscope, especially if the leaves be expanded in hot water, redried and the surfaces attentively examined; some of the particles will be found to reflect light, and appear more or less iridescent. The presence of *Indigo* is also detected by the microscope, under which it appears as minute granules and irregular fragments, many of which reflect a blue or greenish colour, and it is easily distinguished from Prussian blue, the only substance which it nearly resembles. The presence of *Turmeric powder* is likewise ascertained by the microscope. The presence of *Prussian blue* is discovered by the non-effect of chlorine in bleaching it, as also by the action of liquor potassæ and dilute sulphuric acid: the first turns the fragments of a reddish hue, and the latter restores the colour. *Adulterations in green tea* may, in many cases, be detected as follows; put a sample of the suspected tea in a sieve, hold it under a gentle stream of cold water flowing from a tap four or five minutes; if the tea be painted it will change its colour, and upon drying with a very gentle heat, will gradually assume the appearance of ordinary black tea; the residue washed off will generally be found, on microscopic examination, to be Prussian blue, Turmeric and French chalk. A more simple test still, is to rub a little of the suspected tea moistened between your hands; if coloured it will soon impart some of the colouring matter to your hands. Other methods of detecting adulterations are the following. If the leaves be

dealers in these commodities are required to take out an annual Excise license; although they are not at present under any

coated to any considerable extent, it will be sufficient, simply to view one or two of them as opaque objects with a glass of one inch focus, when the colouring matter entering into the composition of the facing will be detected as minute specks, each reflecting its appropriate tint. Another method is, to scrape gently the surface of two or three of the leaves with a penknife, when, if they be faced, the colouring matters may be detected in the powder thus separated,—viewed as an opaque object. A third method is, to place five or six leaves on a slip of glass, moistening them with a few drops of water, and, after the leaves have become softened, firmly squeezing the water out between the finger and thumb; this will then be found to contain more or less of the ingredients forming the facing, should such have been employed. Or, should it be desired to obtain the results on a larger scale, one drachm or so of the leaves may be agitated in a little water for a few minutes, which will detach much of the facing without unfolding the leaves, and which facing will collect as a sediment at the bottom of the vessel, as explained above. Having, by any of these processes, determined whether the sample of tea be faced, the next thing to be ascertained is the nature of the adulterating substances. The blue colouring matter has generally been found to be either Prussian blue or indigo. The former is recognised by the angular form of the fragments, and by their brilliant and transparent blue colour, but most decidedly by the action of the liquor potassæ, which quickly destroys the blue, turning the fragments of a dull reddish brown colour. This re-agent may be easily applied to the smallest particles of Prussian blue under the microscope. The latter is known by the irregular form of the particles, their granular texture, and greenish-blue tint; but chiefly by the fact that the colour is not destroyed by the liquor potassæ. The yellow dyes commonly used are turmeric powder and Dutch pink; the first of these is at once recognised by its microscopic characters, which have been already described; and the latter, by the action of liquor potassæ and acetic acid: the one re-agent converts the bright yellow into a dark brown; and the other occasions effervescence; results explained by the fact that Dutch pink consists of vegetable yellow, in combination with the chalk or carbonate of lime. The white powders used are usually kaolin, soap stone, or sulphate of lime; and although some clue may be obtained as to which of these is employed in any particular sample of tea, by the appearance of the leaves, and the microscopic character of the powder, yet, in order to obtain decided results, it is necessary to institute a chemical analysis. It appears that genuine tea contains about 5 or 6 per cent. of gum. Therefore, if any considerable portion beyond this be found on analysis, it may be presumed that some has been added either for giving a gloss or curl to the leaf, or to fix other adulterating ingredients.

To ascertain whether any of the tea leaves have been used before.—The form of the dry leaves should be particularly noticed. If they want the characteristic twist; if they be broken and agglutinated in little masses, of irregular shape, there is reason to suspect that the tea is spurious. Wash the sample for a minute or so in cold, distilled water; and if they appear glossy, it is probable they consist of exhausted tea-leaves, made up with gum; in which case they should be subject to a chemical analysis, when it will probably be found that the tannin and theine, which give to tea its peculiar colour and aromatic flavour, have almost entirely disappeared, leaving a greater quantity of lignin (or woody substance) and gum, in proportion to the bulk, than is contained in the genuine tea. The following table shows the per-centage of lignin, gum, tannin and colouring matter, and carbonate of lime, found in

regular survey. The articles themselves are not subject to any Excise duty, but to prevent fraud upon the Customs

samples of genuine green and black tea, and in samples of tea which had been used before, and were seized for being spurious, in 1843. The proportions will form a good criterion for chemical examination in future cases :—

	Lignin.	Gum.	Tannin and Colouring.	Carbonate of Lime, &c.	Copper.
Green tea, genuine	55.3	5.4	39.3		
	81.9	13.4	4.7		
Green tea containing exhausted tea leaves.	84.9	6.8	1.1	4.0	3.2
	84.0	11.4	.8	3.8	
	87.5	4.8	.6	3.6	3.5
	71.5	12.0	14.6	1.9	
Black tea, genuine	46.8	5.9	47.3		
	78.6	15.5	5.9		
	81.3	18.0	.7		
Black tea, containing exhausted tea leaves.	72.9	19.9	7.2		
	80.1	15.5	4.4		
	78.1	20.5	1.4		
	72.0	10.0	16.9	1.1	
	84.9	11.6	1.0	2.5	

COFFEE.

Coffee is the seed of a tree of the family *rubiacæ*, cultivated principally in the East; and the berry being first roasted and ground, is extensively used in this country as a beverage. A considerable portion of it is sold in the ground state, and then it is said to be extensively adulterated with Chicory, Corn, Beans, Potatoes, and other articles, all of which have to be roasted or partially charred before they can be mixed with the roasted Coffee. In order to detect these adulterations, the officer should make himself well acquainted with the characteristics of the genuine and adulterating articles respectively.

The *Coffee-berry*, previous to roasting, and even after it has been soaked for a long time in water, is hard and tough, in which respect it differs from all those substances which are used in its adulteration, and which become softened by immersion in cold water; the hardness of the coffee berry is even retained subsequently to the charring, and is so great, that by this character alone, the fragments of the ground and roasted coffee-berry may be readily distinguished from those of chicory. It consists of an assemblage of vesicles or cells of an angular form, which adhere so firmly together, that they break into pieces rather than separate into distinct cells. The cavities of the cells include, in the form of little drops, a considerable quantity of essential oil, upon which the fragrance and active principle of the berry depend. The testa or membrane presents a structure very distinct from that of the substance of the berry itself, and when once seen it cannot be confounded with any other tissue which has yet been observed entering into the adulteration of coffee. It is made up of elongated and adherent cells, forming a single layer, and having oblique markings upon their surfaces. The quantity of this membrane present in a broken and divided state in any sample, affords, therefore, some clue to the quantity of coffee contained in it. When the coffee is roasted, the essential oil wholly disappears, partly arising from the heat, and partly from its being diffused throughout the cavities of the cells. *Chicory*, on the other hand, is the root of a plant; the chief bulk of the root being made up of little cells which are generally of an elongated form, but sometimes rounded; and which, unlike the cells of the coffee-berry, separate from each other with great

duty imposed upon them on importation, and to protect the public, Excise officers are authorised to examine the

readiness, and present appearances which, when once observed, cannot be mistaken. Chicory, owing to the absence of essential oil, readily imbibes water, and when immersed in that fluid, becomes soft, in which also it differs from the roasted coffee-berry. Corn, deprived of its investing tunics or husks, consists of a net-work of cells, in each of which a variable number of starch granules is included. These granules differ in character in different plants. In the majority of the corn tribe, the granules are flattened and rounded discs of moderate size and are obscurely marked with a number of concentric rings. Beans and Peas, deprived of their seed covering, possess a structure altogether analogous to the grain of corn: the granules in the pea and bean are large, oval, sometimes reniform, and the central cavity is of an elongated shape, presenting the appearance of a furrow under the microscope. The structure of the potato resembles, to a great extent, that of the corn, pea, or bean: after boiling the cells readily separate from each other. These cells present a somewhat fibrous appearance, and are of course much larger than the starch granules, many of which are contained in each cell. The granules, as seen in potato flour, are large, ovate, and beautifully marked with concentric rings; but in the boiled potato, they lose much of their form and beauty, and become generally misshapen and collapsed.

To detect roasted corn, peas, or beans, in coffee.—Make an infusion of the suspected coffee, decolourizing it as much as possible by means of animal charcoal, and testing the cold liquor with an aqueous, or an alcoholic solution of iodine, which in that case will produce the characteristic blue colour indicative of the presence of starch.

Another method of detecting the presence of chicory in ground coffee is to moisten a little of the suspected coffee and roll it between the fingers; it will, if in any quantity, form a little pellet or ball; whilst the pure coffee treated in the same manner cannot be agglomerated, and remains in powder. Or, throw a portion of the suspected coffee into a glass of water without stirring, the coffee remains for a while floating on the surface, but the ground chicory absorbs the water immediately, and falls to the bottom of the vessel, imparting a yellowish or brownish yellow colour to the liquor. If the coffee under examination, instead of being thrown into a glass, is put into an inverted bottle from which the bottom has been removed, or into a funnel, the chicory which falls down first may be at once separated by adroitly removing the cork, and collecting the chicory in any convenient vessel placed underneath, after which it may be easily identified by its taste and pastiness. If torrifed ground rice, corn, roasted biscuit, or bread be mixed with the coffee or chicory; the chicory, absorbing water more rapidly, will fall to the bottom first, and may be separated by the means referred to.

As the ashes of all vegetable substances are white, or nearly so, should the ashes of burnt coffee appear red, or a rusty red colour, it is a sure sign that a mineral, such as Venetian red, ruddle, or some other analogous substance, has been mixed with the coffee. See the *Lancet*. *Normandy's Commercial Hand-Book*, &c.

COCOA.

Cocoa is the bruised seed of the tree *Theobroma cacao*, cultivated chiefly in the West Indies. Simply bruised, the seeds constitute the cocoas of the shops; reduced to a paste, mixed with sugar and flavoured with vanilla, they become chocolate. These articles are said to be adulterated in many instances to a great extent; but, as the detection of the adulteration requires an intimate knowledge of the properties of the genuine nut, and of the matters usually mixed with it, it is attended with considerable difficulty. The most

articles, and if they are found to be imitated or adulterated, the parties are liable to penalties. Some suggestions for

pernicious ingredients said to be mixed with this otherwise grateful and nutritious aliment, may, however, be discovered by simple analysis.

To detect mineral substances or earthy matter in cocoa.—Incinerate (that is, burn to ashes,) an ounce of the suspected cocoa, and weigh and test the ashes. If chalk or carbonate of lime be present, an effervescence will ensue on the application of a mineral acid. If the presence of any of the red earths be suspected, as these all contain iron, the ash should be tested for this metal, for which purpose it should first be treated with hydrochloric acid; this should afterwards be diluted, and the proper re-agents applied. Another mode of treatment, recommended by Dr. Normandy, is to grate 500 grains of the suspected article into as fine a powder as possible, and throw it into about half a pint of cold water; stir the whole briskly for about ten minutes, leaving it at rest for about two minutes and decanting the supernatant liquor. The earthy matter will then have subsided, and will be left as sediment.

The presence of *animal fats*, with which cocoa and chocolate are frequently adulterated, may be detected by the palate; for the chocolate generally has in this case a cheesy or rancid flavour, altogether different from the flavour of the genuine article. By exposing the suspected article to the atmosphere for a few days the fatty matter will become rancid.

PEPPER.

Pepper is the fruit of various kinds of plants, which grow principally in India, Java, and the Eastern Islands. The difference between *black pepper* and *white pepper* is, that the latter has been divested of its outer coating by blanching, and is consequently much less pungent and strong than black pepper. These articles, when ground, are frequently adulterated with ground oil-cake, linseed-meal, rice, and other like substances.

The presence of adulterating ingredients in Ground Pepper may frequently be detected by the use of a microscope; but before the officer can make such an examination available he must become acquainted with the characteristics of the genuine and adulterating articles respectively. The *Lancet* gives the following hints for attaining this requisite knowledge :—When black pepper is diffused through water, little particles, of three different kinds, intermixed with a fine powdery substance, are visible; some of these black, others reddish, and the last white: the black are fragments of the outer, and the red those of the inner cortex, while the white are the pulverised seed itself. The powder is formed of the cells of the seed, some united in twos and threes, but the majority either separate and entire or broken to pieces, as well as of starch granules of extreme minuteness. In the black particles, but little evidence of structure is to be seen; and where doubt is entertained of their nature, it is necessary to bleach them with chlorine, and then examine them. In genuine white pepper, no black fragments ought to be seen, but numerous reddish brown particles are always present, usually adherent to the white cells which form the central part of the berry. So great is the quantity of starch in the seed or centre of the berry, that the cells when touched with a solution of iodine become deep blue.—*Linseed* has two coats; the outer gives polish to the seed; in its cells the mucilage which linseed yields so abundantly is contained; the inner coat has narrow elongated cells. The oil is in the outer particles of the seed, and the starch in the inner. When reduced to meal, these structures, by a little patient investigation, may be detected, the parts most frequently seen being fragments of the fibrous coats and little masses of starch, the appearances of which can be easily distinguished from the characteristics of pulverised pepper.—*Mustard seed* is readily detected, even when

detecting adulterations in the different commodities will be found in the notes.

ground into powder. The external membrane is formed of large transparent and nucleated cells; the second is formed of very minute angular cells, containing part of the colouring matter; the third is composed of cells two or three times larger than those of the second coat.—*Rice* is easily distinguished by its colour, and the angular form of its particles.—*Wheat flour* and *Pea flour* are well known, and need no description. In fact, no description of these adulterations can supply the place of experience and close investigation. A useful mode of proceeding is to get samples of each kind of the adulterating ingredients most commonly used, ground to meal, and then closely inspect them by the microscope. We may then become familiar with their characteristic features, so as to be able to detect their presence when in combination with ground pepper.

To ascertain whether ground pepper be genuine and of a good quality, the best way is to find the amount of piperine contained in it.—This may be done by treating 1000 grains, for example, of pulverized pepper with alcohol of specific gravity, 0·833, until they are exhausted. The solution is then distilled to the consistence of an extract; the extract so obtained is then mixed with a solution of caustic potash, which dissolves the resin, and leaves a green powder which should be first well washed with water, and then dissolved in alcohol of specific gravity, 0·833. By spontaneous evaporation the solution yields quadrilateral transparent obliquely truncated crystals of piperine, which are tasteless and inodorous, insoluble in cold water, sparingly soluble in boiling water, from which they separate on cooling; soluble in alcohol, especially with the help of heat: the alcoholic solution is precipitated by water. Good pepper yields about $1\frac{1}{2}$ per cent of piperine; and of course, if the article be adulterated, the reduced proportion of the piperine obtained may serve to indicate the quality of the pepper, or the extent of the fraud.

To detect imitation pepper or P. D. when made of mustard, &c. Throw a certain quantity of the suspected pepper into tepid water; the genuine pepper remains solid, and retains its spherical shape, whilst the spurious grains swell out, soon become soft and gluey, and on stirring become disintegrated, and fall into powder.

APPENDIX.

PART I.

EXCISE ESTABLISHMENT.

No. 1.

COMMISSIONERS AND PRINCIPAL OFFICERS.

Commissioners.

JOHN WOOD, Esq., *Chairman.*

JOHN THORNTON, Esq., *Deputy Chairman.*

C. P. RUSHWORTH, Esq.

H. F. STEPHENSON, Esq.

C. J. HERRIES, Esq.

A. MONTGOMERY, Esq.

C. PRESSLEY, Esq.

London Establishment.

Secretary, J. C. Freeling, Esq.

Assistant Secretary, Thomas Keogh, Esq.

Solicitor, Jos. Timm, Esq.

Assistant Solicitor, H. Tilsley, Esq.

Receiver-General, James Brotherton, Esq.

Under Secretary, George Ballard, Esq.

Assistant Secretary, Edgar Eldred, Esq.

Principal Clerk, Charles Henry Corbett, Esq.

Clerks, 1st Class, Wm. Roberts, Chas. Clarkson, Joseph Wingrave, John Harding, and Thomas Earle, Esqrs.

2nd Class, James Mutter, Edwin Wm. Levermore, Henry Batho, Charles James Brown, and Joseph Crome.

3rd Class, Wm. J. Browne Pfolkes, Wm. Walker, Wm. Lundin Hooper John Chubb, and Wm. Michael Rosetti.

4th Class, George Chalk, Francis Ballard, Alf. Chaworth Lyster, and Wm. Charles Mitchell.

Diary Clerk, John Henry Acott.

Southern Correspondent,

Northern Correspondent, John Norman, Esq.

Clerks, 1st Class, Wm. Anderson and Wm. Stanton, Esqrs.

2nd Class, Edward M'Laughlin, Robert John Swift, Brabazon Disney, and James Hills.

3rd Class, John Harman, Wm. Boys, and Henry Paull.

4th Class, James Kemp, Henry Joseph Prendergast, and Joseph George Wingrave.

5th Class, Richard Oxley and Thomas Clarence Roberts.

Registrar, W. Riddle. *Clerk*, George Foulton.

Accountant and Comptroller-general, L. S. Lyne, Esq.

Assistant, C. S. Hawthorne, Esq.

Principal Accountants, Joseph Atwell, John Cooper, and G. Keele, Esqrs

Accountants, J. P. Price, W. Burbidge, J. S. Hore, T. R. Sidebotham, F. Livermore, James Hulbert, Thomas Stair, and Francis Bowley.
Assessor of Stage Carriage, &c., Duties, Wm. Sutherland, Esq.
Clerks, William Hill and John Kemp.
Inspector of Permits and Certificates, Wm. Thomas Gregory.
Doorkeepers, J. Ertford and James Nicholls.
Warehousekeeper of Seized Goods, John Hall.
Port Surveyor, Thomas Brain. *Assistant*, Joseph Bell. *Port Gauger*, Wm. Bennett. *Surveyor of Exports*, Joshua Bartlett. *Assistant*, Daniel W. Thornton.
Storekeeper, Wm. Johnson, Esq. *Clerks*, G. Taylor, H. Rutter, Dugald M'Intyre, J. H. Harvey, and Edwin Farncombe.
Distributor of Stamps, Wm. Johnson, Esq.
Office-keeper, S. Welsman. *Messengers*, J. Clark and four others.
Surveyor of Buildings, William Herbert, Esq.
Surveying-general Examiners.—*First Class*, Thomas Dobson, John Voyce, R. Dixon, and Edward Harvey Dodd, Esqrs. *Second Class*, Thomas Manwell, George McCallum, Richard Pape, Wm. Corbett, Wm. Milson Moxon, George Phillips, Wm. Carling, Samuel Parsons, Andrew Cowie, James Luckie, Adam Young, C. R. Solomon, and Andrew Cornwall. *Third Class*, B. Parker, Christopher Dresser, Edward Philip, and John Forbes. *Fourth Class*, John Wishart, Wm. Dickinson, Alexander Smith, A. W. Y. McClelland, Wm. Wallace, Wm. Brown, Jas. Hill, Wm. Mathews, Thomas Beddows, John Davis, H. Tarrant, John Bailey, and John Clare.

Collectors.

<i>Barnstaple</i> , James Johnston.	<i>London, North</i> , Jonathan Barber.
<i>Bath</i> , Evan Evans.	<i>London, South</i> , Wm. Wallace.
<i>Bedford</i> , William Allen.	<i>Lynn</i> , John Thorndick.
<i>Birmingham</i> , C. Instan.	<i>Manchester</i> , Robt. Hutchinson.
<i>Bolton</i> , John Harrison.	<i>Middlesex</i> , Thos. Frankish.
<i>Bristol</i> , Francis Amey.	<i>Newcastle</i> , James Thompson.
<i>Cambridge</i> , R. Buckle.	<i>Northampton</i> , John Knapton.
<i>Canterbury</i> , John Lewis.	<i>Northwich</i> , Chas. Eldred.
<i>Chester</i> , John Moah.	<i>Norwich</i> , John Wild.
<i>Cornwall</i> , E. Hillborne.	<i>Oxford</i> , William Gilbert.
<i>Coventry</i> , T. Rayner.	<i>Plymouth</i> , John Jones.
<i>Cumberland</i> , E. Godsall.	<i>Reading</i> , William Hawkins.
<i>Derby</i> , Wm. Knaggs.	<i>Rochester</i> , Thomas Eman.
<i>Dorset</i> , James Salmon.	<i>Salop</i> , John Mayhew.
<i>Durham</i> , R. Elwin.	<i>Salurn</i> , W. Adolphus Mark.
<i>Essex</i> ,	<i>Sheffield</i> , John Badcock.
<i>Exeter</i> , Joshua Austin.	<i>Stafford</i> , Robert Flamank.
<i>Gloucester</i> , T. Weston.	<i>Stourbridge</i> , Joshua Shacklock.
<i>Grantham</i> , J. Harrison.	<i>Suffolk</i> , T. Pocock Orum.
<i>Hakifaz</i> , Thomas Williamson.	<i>Surrey</i> , George Clements.
<i>Hants</i> , Wm. Husband.	<i>Sussex</i> , S. Crooke Brown.
<i>Hereford</i> , S. Cathcart.	<i>Taunton</i> , James Chevalier.
<i>Hull</i> , M. Hargreaves.	<i>Thirsk</i> , Thomas Weddle.
<i>Isle of Wight</i> , Jos. Shaw.	<i>Wales, East</i> , James Alex. Black.
<i>Lancaster</i> , John Manners.	<i>Wales, Middle</i> , John Pollock.
<i>Leeds</i> , John Clark.	<i>Wales, North</i> , Joseph Wood.
<i>Leicester</i> , Wm. Mountford.	<i>Wales, West</i> , Geo. Alex. Evans.
<i>Lichfield</i> , Richard Dance.	<i>Ware</i> , William Wrenford.
<i>Lincoln</i> , Joseph Pacy.	<i>Worcester</i> , Jos. Drinkwater.
<i>Liverpool</i> , W. Humphreys.	<i>York</i> ,
<i>London, East</i> , T. Dean.	
<i>Aberdeen</i> , John Anderson.	<i>Inverness</i> , Colin Campbell.
<i>Argyle, South</i> , John Anderson.	<i>Linlithgow</i> , John Mitchell.
<i>Ayr</i> , John M'Culloch.	<i>Montrose</i> , John Corbet.
<i>Dumfries</i> , Thomas Smith.	<i>Perth</i> , John Wemyss.
<i>Edinburgh</i> , Donald Ross.	<i>Stirling</i> , Alexander Haliburton.
<i>Elgin</i> , Robert Pape.	<i>Argyle and Caithness</i> , by Super- visors.
<i>Glasgow</i> , Robert Smith Sharp.	
<i>Haddington</i> , Thomas Moody.	

Athlone, George L. Gains.
 Bandon, Robert C. Denton.
 Belfast, Evan Cameron.
 Birr, John Stothard.
 Colerain, Patrick Kelly.
 Cork, Francis Ayrton.
 Drogheda, William Dryden.
 Dublin, Henry Smith.

Galway, Golding Bird.
 Limerick, John Wegelsworth
 Londonderry,
 Naas, John Thorburn.
 Newry, John Terry.
 Sligo, Austin Malley.
 Waterford, Henry Rundle.
 Wexford, George Mathews.

No. 2.

CONDENSED SCHEMES OF THE COLLECTIONS, ETC., IN THE UNITED KINGDOM.

*. * It must be understood that the Collector resides at the place after which his collection is named, if his residence be not appended. The days and miles following the name of the collection, indicate the time that the Collector is on his round, and the distance travelled. When two sets of times and distances are given, the first usually refers to the 1st, 3rd, 5th, and 7th rounds; and the second to the 2nd, 4th, 6th, and 8th rounds. When the Collector's salary is £350, and that of the clerk £140, the amounts are not inserted. In other cases they are mentioned immediately after the name of the collection. The figures following the letters, Ex., T., and Q. R., show the amount, or estimated amount, received annually for Excise Duties, Taxes, and Quit Rents respectively. The names of the Districts are given in Capitals; the other places named are the residences of the Officers; and the figures prefixed to such places indicate the number of officers stationed there. The letters in Small Capitals, after the names of the stations, refer to the direction in which those stations lie in respect to the residence of the Supervisor. The signification of the Small Letters after the numbers is as follows;—d. Distiller; m. Malster; p. Papermaker; r. Rectifier; s. Soapmaker; h. Hop-planter; b. Brewer; o. Other growing Duties; c. Cautionary Trader; and l. Licensed Trader.

ENGLAND.

BARNSTAPLE.

16 days 238 miles; 11 days 229 miles.
 Ex. 70,000 T. 50,000.

BARUM 932 c. 1220 l.

4 Barnstaple in 28 m. 2 p. 152 b. 42 o.
 1 Ilfracombe 11 s.w., 4 m. 22 b. 13 o.
 1 Barracombe 12 s., 5 m. 41 b. 15 o.

BIDEFORD 959 c. 1209 l.

2 Bideford in 22 m. 79 b. 18 o.
 1 Hartland 14 w., 5 m. 16 b. 1 o.
 1 Stratton 21 s.w., 10 m. 22 b. 5 o.
 2 Torrington 17 s.e., 17 m. 45 b. 6 o.

DUNSTER 631 c. 772 l.

1 Dunster in 9 m. 19 b. 2 o.
 1 Minehead 3 s.w., 8 m. 21 b. 9 o.
 1 Williton 7 s., 10 m. 10 b. 8 o.
 1 Watchet 7 s., 6 m. 1 p. 7 b.
 1 Dulverton 17 s., 8 m. 25 b. 1 o.

SOUTHMOLTON 807 c. 994 l.

2 Southmolton in 19 m. 64 b. 9 o.
 1 Chumleigh 9 s., 7 m. 22 b. 4 o.
 1 Sheepwash 26 s.w., 6 m. 21 b. 1 o.
 1 Dolton 18 s.w., 9 m. 16 b. 1 o.

BATH.

400, 16 days 167 miles; 11 days 161 miles.
 Ex. 130,000 T. 110,000.

BATH 1557 c. 187 l.

3 Bath in. 15 m. 1 s. 104 b. 62 o.
 1 Batheaston, 3 s., 10 m. 1 p. 15 b.
 1 Twerton 2 s.w., 9 m. 17 b.
 1 Southstoke 3 s., 8 m. 23 b. 1 o.
 1 Weston 2 s.w., 7 m. 25 b. 13 o.

BOX 994 c. 87 l.

1 Box in. 6 m. 1 p. 1 s. 9 b. 1 o.
 1 Trowbridge 9 s.e., 7 m. 40 b. 6 o.
 1 Melksham 6 s.e., 7 m. 20 b. 2 o.
 2 Bradford 6 s., 17 m. 37 b. 4 o.
 1 Marshfield 6 s., 13 m. 10 b.
 1 Calerne 3 s., 8 m. 1 p. 11 b.

CHIPPENHAM 929 c. 90 l.

1 Chippenham in 8 m. 19 b. 9 o.
 1 Corsham 5 s.w., 8 m. 11 b. 2 o.
 1 Biddestone 5 w., 11 m. 1 p. 10 b.
 1 Calne 6 s., 5 m. 1 p. 20 b. 4 o.
 1 Malmesbury 10 s.w., 8 m. 16 b. 8 o.
 1 Somerford 8 s., 7 m. 12 b.
 1 Didmaston 14 w., 8 m. 15 b. 7 o.

FROME 1006 c. 81 l.

- 2 Frome in 16 m. 50 b. 8 o.
- 3 Warminster 7 s., 27 m. 37 b. 10 o.
- 1 Westbury 8 s.e., 7 m. 26 b. 2 o.
- 1 Norton 7 n.w., 12 m. 15 b.

BEDFORD. (ATLESBURY)

17 days 272 miles; 11 days 175 miles.
Ex. 181,600 T. 162,000.

AYLESBURY 1170 c. 802 l.

- 1 Aylesbury in 6 m. 13 b. 16 o.
- 2 Leighton 11 s.e., 12 m. 43 b. 12 o.
- 1 Tring 8 s.s.w., 6 m. 11 b. 8 o.
- 1 Thame 10 s.w., 6 m. 6 b. 17 o.
- 1 Brill 13 w. 5 m. 5 b. 6 o.
- 1 Hardwick 4 n.s.w., 4 m. 8 b. 3 o.

BEDFORD 1075 c. 582 l.

- 2 Bedford in 16 m. 34 b. 12 o.
- 1 Woburn 14 s.s.w., 5 m. 20 b. 6 o.
- 1 Ampthill 8 s. 7 m. 6 b. 6 o.
- 1 Harrold 9 n.w., 5 m. 19 b. 2 o.
- 1 Olney 12 w. 8 m. 31 b. 8 o.
- 1 Newport Pagnell 14 w.s.w., 7 m. 20 b. 17 o.
- 1 Wavenden 14 s.w., 6 m. 24 b. 4 o.

HEMEL HEMPSTEAD 456 c. 261 l.

- 1 Hempstead in 4 m. 1 p. 8 b. 7 o.
- 1 Two Waters 2 s. 2 m. 2 p. 3 b. 8 o.
- 1 King's Langley 4 s.s.e., 3 m. 1 p. 1 b. 2 o.
- 1 Berkhamstead 5 w., 8 m. 1 s. 7 b. 13 o.

WYCOMBE 594 c. 316 l.

- 2 Wycombe in 5 m. 6 p. 3 b. 24 o.
- 1 Beaconsfield 6 s.s.e., 2 m. 1 p. 1 b. 7 o.
- 1 Risborough 9 n.w., 5 m. 2 p. 2 b. 11 o.
- 1 Woodburn 5 s.e., 1 m. 4 p. 1 b.

BIRMINGHAM.

400, 4 days 53 miles; 5 days 103 miles.
Ex. 203,000 T. 135,000.

BIRMINGHAM, 1st, 1282 c.

- 5 B. in 36 m. 6 p. 1 s. 488 b. 66 o.
- 1 Loxells 2 n.w., 11 m. 74 b. 9 o.

BIRMINGHAM, 2nd, 964 c.

- 1 Solihull 7 s.e., 15 m. 21 b. 4 o.
- 1 Knowle 9 s.e., 12 m. 14 b. 3 o.
- 4 B. in 29 m. 2 p. 320 b. 53 o.
- 1 Kingsheath 5 s., 7 m. 42 b. 8 o.

BIRMINGHAM, 3rd, 724 c.

- 1 Colehill 10 s.e., 9 m. 38 b. 3 o.
- 3 B. in 26 m. 2 p. 207 b. 26 o.
- 1 Yardley 4 s. 10 m. 13 b.
- 1 New Inn 4 s.e., 10 m. 28 b. 3 o.

BIRMINGHAM, 4th, 884 c.

- 5 B. in 49 m. 4 p. 315 b. 59 o.
- 1 Aston Manor 2 s., 11 m. 1 p. 75 b. 2 o.

SMETHWICK 657 c.

- 2 Smethwick in 12 m. 1 s. 112 b. 5 o.
- 1 Oldbury 4 w., 10 m. 105 b. 4 o.
- 1 Halesowen 7 s.w., 8 m. 40 b. 2 o.
- 1 Rowley Regis 7 s.w., 9 m. 63 b. 1 o.
- 1 Fox Oak 9 s.w., 9 m. 78 b.

BOLTON.

13 days 153 miles; 8 days 112 miles. Ex.
not returned; T. not returned.

BLACKBURN 1734 c. 1321 l.

- 1 Over Darwen 5 s. 2 p. 1 b.
- 1 Blackburn in 2 m. 29 b. 13 o.
- 1 Church Bank 6 n., 1 s. 8 b.
- 1 Haslingden 9 s.e., 55 b. 4 o.
- 1 Enfield 6 s., 1 m. 1 s. 8 b. 4 o.

BURNLEY 1609 c. 1145 l.

- 1 Clitheroe 12 n.w., 1 m. 30 b. 10 o.
- 1 Barrowford 5 n., 3 m. 43 b. 2 o.
- 1 Burnley in 2 m. 33 b. 9 o.
- 1 Padiham 3 n.w., 1 s. 15 b. 4 o.
- 1 Todmorden 9 s.e., 7 m. 63 b. 4 o.
- 1 Hebdenbridge 13 s.e., 2 m. 56 b. 4 o.

BURY 119 c. 908 l.

- 3 Bury in 3 p. 179 b. 2 o.
- 1 Shuttleworth 5 n., 1 p. 66 b.
- 1 Leverlane 8 s.w., 2 p. 41 b.
- 1 Wrigleybrook 4 s.w., 33 b. 2 o.

WIGAN 2103 c. 1563 l.

- 1 Leigh 8 s.e., 3 m. 38 b. 5 o.
- 1 St. Helens' 10 s.w., 4 m. 1 r. 3 b. 4 o.
- 1 Sutton 14 s.w., 1 m. 12 b. 1 o.
- 2 Wigan in 5 m. 76 b. 5 o.
- 1 Newton 8 s., 3 m. 12 b. 5 o.
- 1 Standish 5 n.w., 24 b. 1 o.

BOLTON-LE-MOORS 1529 c. 1131 l.

- 1 Astley Bridge 2 n., 2 p. 49 b.
- 1 Halshaw Moor 4 s. 1 p. 36 b.
- 3 Bolton in 2 p. 1 r. 284 b. 4 o.
- 1 Kersley 5 s., 1 p. 42 b. 1 o.

In this collection are five tobacco
manufacturers.

BRISTOL

500, 2nd, c.fk. 180, 7 days 81 miles; 6 days
61 miles. Ex. 400,443 T. 138,755.

BRISTOL, 1st, 742 c. 288 l.

- 5 Bristol in 22 m. 5 s. 149 b. 47 o.

BRISTOL, 2nd, 705 c. 241 l.

- 2 Bristol in 11 m. 2 s. 62 b. 10 o.
- 1 Nailsea 9 w.s.w., 4 m. 10 b. 18 o.
- 1 Bitton 7 s.e., 2 m. 1 p. 11 b. 1 o.
- 1 Whitchurch 4 s.s.e., 2 m. 1 p. 29 b.
- 1 Clutton 10 s., 5 m. 1 p. 26 b.

BRISTOL, 3rd, 684 c. 241 l.

- 4 Bristol in 22 m. 3 s. 145 b. 2 o.
- 1 Clifton 2 w., 2 m. 22 b. 27 o.
- 1 Staplehill 5 n.e., 3 m. 1 s. 39 b. 4 o.

WOTTON 538 c. 149 l.

- 1 Sodbury 8 s. 8 m. 61 b. 5 o.
- 1 Wickwar 4 s.w., 7 m. 19 b.
- 1 Wotton in 8 m. 35 b. 5 o.
- 2 Dursley 6 n. 15 m. 31 b. 6 o.
- 1 Berkeley 10 n.w., 5 m. 15 b. 9 o.
- 1 Thornbury 11 w.s.w., 4 m. 36 b. 8 o.

BRISTOL, 4th, 396 c. 68 l.

- 5 Bristol in 1 d. 38 m. 1 s. 88 b. 18 o.

CAMBRIDGE.

18 days 192 miles, 11 days 151 miles. Ex.
319,937 T. 153,476.

CAMBRIDGE 1815 c. 1049 l.

- 2 Cambridge in 16 m. 1 s. 48 b. 56 o.
- 1 Oakington 7 w.s.w., 4 m. 26 b. 1 o.
- 1 Chesterton 8 s., 9 m. 19 b. 1 o.
- 1 Sawston 7 s.e., 3 m. 1 p. 8 b. 1 o.
- 1 Barnwell 2 n.e., 8 m. 15 b. 2 o.

ELY 1239 c. 1208 l.

- 1 Ely in 4 m. 17 b. 10 o.
- 1 March 20 n.w., 2 m. 17 b. 10 o.
- 1 Chatteris 12 w., 4 m. 8 b. 4 o.
- 1 Soham 6 s.e., 8 m. 18 b. 3 o.
- 1 Burwell 18 s.e., 11 m. 8 b. 1 o.
- 1 Newmarket 14 s.e., 10 m. 26 b. 14 o.

HUNTINGDON 1014 c. 937 l.

- 1 Huntingdon in 8 m. 28 b. 9 o.
- 1 Buckden 5 s.w., 6 m. 7 b. 2 o.
- 1 St. Neots 10 s., 4 m. 1 p. 9 b. 9 o.
- 1 Eaton 10 w., 7 m. 14 b. 5 o.
- 1 St. Ives 6 e., 9 m. 11 b. 8 o.
- 1 Fenstanton 6 s.e., 5 m. 5 b. 1 o.
- 1 Warboys 9 n.e., 8 m. 34 b. 9 o.

SAFFRON WALDEN 469 c. 476 l.

- 1 Thaxted 8 s.e., 6 m. 9 b. 2 o.
- 2 Walden in 23 m. 10 b. 10 o.
- 1 Linton 6 n.w., 5 m. 31 b. 4 o.
- 1 Newport 4 s.s.w., 6 m. 9 b. 2 o.
- 1 Duxford 7 n.w., 8 m. 8 b. 3 o.

CANTERBURY.

450, 14 days 232 miles; 9 days 181 miles.
Ex. 180,600 T. 120,000.

CANTERBURY 1273 c. 485 l.

- 3 Canby in 14 m. 1 p. 1 s. 51 b. 9 b. 39 o.
- 1 Sturry 3 n.e., 3 m. 59 h. 3 b. 13 o.
- 1 Faversham 9 w.s.w., 5 m. 70 h. 3 b. 17 o.
- 1 Wye 12 s.w., 3 m. 49 h. 3 b. 7 o.

DOVER 1211 c. 390 l.

- 4 Dover in 1 r. 6 m. 6 p. 4 h. 13 b. 44 o.
- 1 Folkstone 7 w.s.w., 2 m. 6 h. 4 b. 17 o.
- 1 Hythe 12 w.s.w., 4 m. 1 p. 10 h. 4 b. 7 o.

SANDWICH 1359 c. 439 l.

- 1 Sandwich in 7 m. 77 h. 5 b. 19 o.
- 1 Ramsgate 7 n.w., 1 r. 5 m. 4 b. 17 o.
- 1 St. Peters 9 n.w., 4 m. 3 b. 12 o.
- 1 Margate 9 n.w., 4 m. 10 b. 21 o.
- 1 Wingham 6 w., 5 m. 5 b. 4 o.
- 1 Deal 6 s.s.e., 7 m. 4 b. 15 o.

TENTERDEN 786 c. 366 l.

- 1 Tenterden in 270 h. 2 b. 21 o.
- 1 Romney 15 s.e., 1 m. 4 b. 13 o.
- 1 Goudhurst 12 w.s.w., 2 m. 244 h. 1 b. 21 o.
- 1 Cranbrook 8 w.s.w., 1 p. 252 h. 5 b. 20 o.
- 1 Ashford 12 n.e., 4 m. 1 p. 190 h. 5 b. 18 o.

CHESTER.

17 days 207 miles; 11 days 185 miles.
Ex. 97,000 T. 80,000.

OSWESTRY 927 c. 1027 l.

- 1 Rayton 9 s., 13 m. 18 b. 1 o.
- 3 Oswestry in 34 m. 1 p. 85 b. 14 o.

- 1 Lodge 5 n., 11 m. 1 p. 8 b. 6 o.
- 1 Ruabon 12 n.e., 6 m. 58 b. 1 o.
- 1 Chirk, 7 n.e., 8 m. 27 b. 1 o.

ELLESMERE 572 c. 552 l.

- 1 Overton 5 n.e., 9 m. 19 b. 1 o.
- 1 Hanmer 8 s., 8 m. 12 b.
- 8 Ellesmere in 50 m. 48 b. 4 o.
- 1 Wem 10 s., 13 m. 20 b. 4 o.
- 1 Shawbury 16 s., 12 m. 18 b. 1 o.

CHESTER 2079 c. 2106 l.

- 3 Chester in 23 m. 2 s. 38 b. 32 o.
- 1 Ellesmereport 9 n., 1 s. 7 b. 6 o.
- 1 Stonebridge 1 s., 2 m. 1 s. 1 o.
- 3 Wrexham 12 n.w., 27 m. 91 b. 7 o.
- 1 Cefnybedd 12 n.w., 1 m. 1 p. 19 b.

WHITCHURCH 808 c. 872 l.

- 1 Malpas 5 n., 5 m. 24 b. 1 o.
- 1 Holt 14 n.w., 7 m. 26 b. 1 o.
- 1 Whitechurch in 12 m. 42 b. 10 o.
- 1 Tilstock 3 s., 12 m. 23 b. 1 o.
- 2 Drayton 12 s., 17 m. 53 b. 6 o.

NANTWICH 974 c. 1195 l.

- 1 Betley 8 s., 14 m. 19 b. 5 o.
- 1 Audlem 11 s., 6 m. 28 b. 1 o.
- 1 Woore 9 s.e., 8 m. 26 b. 4 o.
- 2 Nantwich in 15 m. 85 b. 19 o.

CORNWALL. (TRURO.)

400, 19 days 226 miles; 13 days 226 miles.
Ex. not returned, T. not returned.

PENZANCE 1338 c. 1659 l.

- 1 Helston 18 s., 2 m. 20 b. 8 o.
- 1 Manaccan 23 s., 5 m. 18 b.
- 1 Penzance in 1 m. 11 b. 15 o.
- 1 St. Ives 7 n., 3 m. 21 b. 6 o.

PENRYN 1536 c. 1949 l.

- 1 Chacewater 11 s., 7 m. 44 b. 1 o.
- 1 Redruth 8 n., 4 m. 25 b. 8 o.
- 1 Penryn in 3 m. 1 p. 29 b. 5 o.
- 1 Falmouth 2 s., 1 m. 21 b. 11 o.

TRURO 981 c. 1454 l.

- 2 Truro in 15 m. 61 b. 17 o.
- 1 Mitchel 9 n., 8 m. 22 b.
- 1 St. Austle, 14 n.e., 7 m. 38 b. 10 o.
- 1 Grampound 8 n.e., 7 m. 29 b. 6 o.
- 1 Tregony 9 s.e., 4 m. 22 b.

WADEBRIDGE 759 c. 1326 l.

- 1 St. Columb 8 w., 9 m. 31 b. 3 o.
- 1 Padstow 8 w., 12 m. 19 b. 6 o.
- 1 Wadebridge in 9 m. 15 b. 8 o.
- 1 Amble 5 n., 6 m. 16 b. 4 o.
- 1 Bodmin 7 s., 4 m. 37 b. 8 o.
- 1 Lostwithiel 13 s., 5 m. 51 b. 7 o.

LAUNCESTON 623 c. 968 l.

- 1 Camelford 18 n.w., 6 m. 30 b. 9 o.
- 1 Holsworthy 14 n., 5 m. 20 b. 2 o.
- 1 Lifton 5 s., 3 m. 21 b. 1 o.
- 1 Launceston in 4 m. 18 b. 16 o.
- 1 Launceston 12 n.w., 4 m. 15 b.
- 1 Launceston 3 w., 3 m. 20 b.

COVENTRY.

17 days 207 miles; 11 days 67 miles.
Ex. 135,000 T. 116,500.

DAVENTRY 888 c. 485 l.

- 1 Rugby 10 n.w., 7 m. 49 b. 10 o.
- 1 Haddon 9 n.e., 10 m. 42 b. 4 o.
- 1 Harpole 9 e., 10 m. 26 b. 4 o.
- 1 Daventry in 9 m. 52 b. 5 o.
- 1 Badby 4 w., 9 m. 23 b. 2 o.
- 1 Southam 10 w., 12 m. 28 b. 7 o.
- 1 Napton 8 w., 7 m. 22 b. 1 o.

STRATFORD-ON-AVON 428 c. 229 l.

- 1 Kineton 10 s., 11 m. 22 b. 4 o.
- 2 Stratford in 22 m. 59 b. 14 o.
- 1 Alcester 8 w., 14 m. 24 b. 5 o.
- 1 Henley-in-Arden 8 n., 9 m. 35 b. 4 o.
- 1 Aston Cantlow 8 n.w., 4 m. 1 p. 26 b. 3 o.

WARWICK 616 c. 321 l.

- 3 Warwick in 33 m. 95 b. 10 o.
- 2 Leamington 3 e., 12 m. 84 b. 34 o.
- 1 Bedlam's End 8 n.w., 8 m. 15 b. 1 o.
- 1 Kenilworth 5 n., 9 m. 22 b. 6 o.

NUNEATON 794 c. 442 l.

- 1 Polesworth 11 n.w., 11 m. 24 b.
- 2 Atherstone 6 n.w., 14 m. 77 b. 5 o.
- 1 Nuneaton in 8 m. 63 b. 6 o.
- 1 Bedworth 3 s., 8 m. 94 b. 4 o.
- 1 Brinklow 10 s.e., 5 m. 59 b. 2 o.

COVENTRY 853 c. 317 l.

- 4 Coventry in 42 m. 217 b. 12 o.
- 1 Ryton 4 s., 7 m. 26 b. 1 o.
- 1 Meriden 6 w., 8 m. 29 b. 1 o.

CUMBERLAND. (CARLISLE.)

19 days 258 miles; 12 days 236 miles. Ex. 67,000 T. 48,586.

CARLISLE 2562 c. 1103 l.

- 2 Carlisle in 6 m. 10 b. 25 o.
- 1 Wigton 11 s.w., 6 m. 5 b. 9 o.
- 1 Burgh 6 w.n.w., 1 m. 1 b. 2 o.
- 1 Dalston 5 s. by w., 5 m. 3 b. 1 o.
- 1 Brampton 10 e.n.e. 3 m. 3 b. 4 o.

PENRITH 1877 c. 727 l.

- 2 Penrith in 11 m. 11 b. 19 o.
- 1 Keswick 19 w.s.w. 4 m. 3 b. 11 o.
- 1 Kirkoswald 9 n., 2 m. 1 p. 1 b.
- 1 Appleby 14 s.e., 6 m. 7 b. 3 o.
- 1 Kirkby Stephen 24 s.e., 5 m. 7 b. 4 o.

WHITEHAVEN 2255 c. 993 l.

- 1 Whitehaven in 2 m. 5 b. 8 o.
- 1 Workington 8 n., 3 m. 1 p. 5 b. 3 o.
- 1 Maryport 14 n., 2 m. 4 b. 10 o.
- 1 Cockermouth 14 n.e., 5 m. 12 b. 8 o.
- 1 Ravenglass 18 s., 4 m. 12 b. 4 o.
- 1 Egremont 6 s., 2 m. 1 p. 1 b. 5 o.

BOWNESS STATION. Tide Surveyor.

- 3 Bowness in.

CARLISLE BORDER.

- 1 Carlisle border in.
- 2 Stanwick 1 n.
- 2 Rockcliff 6 n.w.

LONGTOWN BORDER.

- 2 Longtown border in.
- 2 Warwick's land 9 n.
- 2 Roan's green 16 n.w.

SKINBURNESS STATION. Tide Surveyor.

- 3 Skinburness in.

DERBY. (NOTTINGHAM.)

16 days 129 miles; 11 days 129 miles. Ex. 176,000 T. 130,000.

NOTTINGHAM, 1st, 1729 c. 815 l.

- 3 Nott. in 33 m. 1 p. 190 b. 25 o.
- 1 Castle Donington 13 s.s.w., 11 m. 1 p. 19 b. 1 o.

- 1 Kegworth 12 s.w. 10 m. 20 b. 7 o.
- 1 Beeston 4 s.w. 10 m. 50 b. 1 o.

NOTTINGHAM, 2nd, 1770 c. 1129 l.

- 2 Nott. in 23 m. 129 b. 18 o.
- 1 Bingham 10 e. 11 m. 29 b. 1 o.
- 1 Ratcliff 6 e. 13 m. 29 b. 1 o.
- 1 Lowdham 8 n.e., 6 m. 1 p. 37 b. 3 o.
- 1 Bulwell 5 n.n.w. 9 m. 66 b. 1 o.

MANSFIELD 1593 c. 801 l.

- 2 Mansfield in 26 m. 80 b. 12 o.
- 1 Sutton in Ashfield 4 w.s.w., 4 m. 82 b. 1 o.
- 1 Southwell 12 s.e., 11 m. 33 b. 7 o.
- 1 Ripley 13 s.w., 6 m. 63 b. 1 o.
- 1 Alfreton 10 s.w., 11 m. 54 b. 6 o.

WIRKSWORTH 1685 c. 754 l.

- 1 Wirksworth in 8 m. 52 b. 6 o.
- 2 Cromford 2 n., 7 m. 2 p. 81 b. 14 o.
- 2 Ashbourn 10 s.w., 16 m. 95 b. 6 o.
- 1 Duffield 9 s.s.e., 5 m. 2 p. 26 b. 2 o.
- 1 Belper 7 s.e., 4 m. 75 b. 7 o.

DERBY 2321 c. 1071 l.

- 4 Derby in 36 m. 1 p. 1 s. 270 b. 47 o.
- 1 Melbourne 8 s.s.e., 8 m. 34 b. 4 o.
- 1 Spondon 4 e., 6 m. 44 b.
- 1 Eastwood 11 n.e., 5 m. 71 b. 3 o.

DORSET. (BLANDFORD.)

19 days 201 miles; 10 days 161 miles. Ex. 76,000 T. 100,000.

SHAFTESBURY 540 c. 274 l.

- 2 Shaftesbury in 13 m. 32 b. 9 o.
- 1 Hindon 8 n.n.e., 4 m. 14 b. 3 o.
- 1 Tisbury 9 n.e., 7 m. 13 b. 2 o.
- 1 Marnhull 8 s.w., 6 m. 1 s. 14 b. 2 o.
- 1 Wyke 6 n.w., 6 m. 9 b. 3 e.

DORCHESTER 1007 c. 589 l.

- 2 Dorchester in 17 m. 1 s. 18 b. 8 o.
- 1 Weymouth 8 s., 5 m. 8 b. 18 o.
- 1 Cerne Abbas 8 n.n.w., 7 m. 25 b. 6 o.
- 1 Broadmayne 4 s.e., 8 m. 8 b. 1 o.
- 1 Stratton 4 n.w., 7 m. 7 b. 3 o.
- 1 Broadway 6 s., 6 m. 16 b. 2 o.

POOLE 499 c. 300 l.

- 2 Poole in 13 m. 15 b. 9 o.
- 1 Wareham 10 w.s.w., 6 m. 12 b. 6 o.
- 1 Corfe Castle 14 s.w., 5 m. 14 b. 6 o.
- 1 Wimborne 6 n., 7 m. 19 b. 6 o.

BLANDFORD 629 c. 352 l.

- 2 Blandford in 10 m. 1 s. 21 b. 14 o.
- 1 Cranborne 14 n.e., 5 m. 13 b. 1 o.
- 1 Bere Regis 8 s.s.w., 6 m. 10 b. 1 o.
- 1 Stickland 4 s.w., 7 m. 15 b.

- 1 Shroton 5 n.w., 8 m. 13 b.
- 1 Withcampton 8 n., 4 m. 1 p. 4 b.

DURHAM. (SUNDERLAND.)

400, 16½ days 209 miles; 8 days 129 miles.
Ex. 149,000 T. 141,000.

DURHAM 977 c. 152 l.

- 2 Durham in 13 m. 3 p. 32 b. 12 o.
- 1 Sunderland B. 4 s.w., 1 m. 2 p. 9 b. 2 o.
- 1 Sedgefield 11 s., 3 m. 12 b. 4 o.
- 1 Chester-le-Street 6 n.w., 2 m. 1 p. 4 b. 8 o.

BISHOP AUCKLAND 1420 c. 345 l.

- 2 Bishop Auckland in 8 m. 31 b. 12 o.
- 2 Darlington 15 s., 5 m. 79 b. 25 o.
- 1 Barnard Castle 16 s., 3 m. 30 b. 10 o.
- 1 Staindrop 10 s., 3 m. 21 b. 2 o.
- 1 Wolsingham 10 w., 2 m. 12 b. 10 o.

GATESHEAD 1499 c. 218 l.

- 2 Gateshead in 3 m. 1 p. 1 s. 32 b. 2 o.
- 1 Swalwell 5 s., 6 m. 1 p. 9 b.
- 1 Shotley Bridge 16 w., 2 p. 6 b. 7 o.
- 1 Burnepfield 8 w., 2 m. 2 p. 6 b. 2 o.
- 1 Scotswood 6 w., 3 m. 1 p. 1 b.
- 1 Sandyford 1 n., 4 m. 12 b. 1 o.

SUNDERLAND 1705 c. 310 l.

- 3 Sunderland in 17 m. 1 p. 28 b. 17 o.
- 1 Easington 10 s.e., 4 m. 13 b. 5 o.
- 1 Houghton-le-Spring 7 s.w., 7 m. 13 b. 8 o.
- 1 Hyton 4 w.w., 1 p. 3 b.

ESSEX. (COLCHESTER.)

400, 23 days 221 miles; 16 days 197 miles. Ex. 206,000 T. 124,000.

COLCHESTER 583 c. 501 l.

- 8 Colchester in 16 m. 29 b. 16 o.
- 1 Nayland 7 n., 8 m. 18 b. 2 o.
- 1 Coggeshall 10 w., 7 m. 17 b. 2 o.
- 1 Kelvedon 10 w., 6 m. 14 b. 3 o.
- 1 Witham 14 w., 5 m. 14 b. 5 o.
- 1 Goldhanger 15 s., 5 m. 7 b.

CHELMSFORD 606 c. 527 l.

- 1 Chelmsford in 8 m. 20 b. 6 o.
- 1 Broomfield 4 n., 9 m. 8 b. 1 o.
- 1 Writtle 3 n.w., 7 m. 6 b. 2 o.
- 1 Maldon 8 s.e., 6 m. 1 s. 9 b. 6 o.
- 1 Southminster 18 s.e., 1 m. 6 b. 7 o.
- 1 Stebbing 14 n., 10 m. 8 b. 2 o.
- 1 Dunmow 13 n., 6 m. 13 b. 11 o.

HALSTEAD 355 c. 336 l.

- 1 Halstead in 8 m. 25 b. 9 o.
- 1 Castle Hedingham 5 n.w., 7 m. 6 b. 3 o.
- 1 Sible Hedingham 4 n.w., 6 m. 19 b. 2 o.
- 1 Earles Colne 4 s., 6 m. 1 p. 16 b. 1 o.
- 2 Braintree 8 s., 13 m. 1 s. 41 b. 11 o.
- 1 Wethersfield 10 s.w., 7 m. 16 b. 4 o.

MANNINGTREE 422 c. 380 l.

- 2 Manningtree in 20 m. 16 b. 7 o.
- 1 Great Oakley 8 s., 7 m. 3 b. 2 o.
- 1 East Bergholt 5 n., 7 m. 16 b. 4 o.
- 1 Tending 8 s., 5 m. 5 b. 5 o.
- 1 Frating 8 s.w., 6 m. 7 b. 2 o.

HADLEIGH 182 c. 173 l.

- 8 Hadleigh in 29 m. 17 b. 6 o.
- 2 Boxford 6 s.w., 15 m. 6 b. 1 o.
- 1 Lavenham 10 n.w., 7 m. 27 b. 4 o.
- 1 Bildeston 5 n., 7 m. 21 b. 4 o.

SUDBURY 528 c. 433 l.

- 1 Sudbury in 7 m. 25 b. 11 o.
- 1 Ballingdon 1 s.w., 6 m. 12 b. 1 o.
- 1 Bures 6 s., 8 m. 12 b.
- 1 Melford 4 n.w., 9 m. 9 b. 5 o.
- 1 Glemsford 8 n., 5 m. 1 p. 1 s. 8 b.
- 1 Cavendish 8 s.w., 6 m. 15 b.
- 1 Clare 10 s.w., 7 m. 21 b. 3 o.
- 1 Haverhill 18 s.w., 7 m. 18 b. 8 o.

EXETER.

400, 18 days 206 miles, 12 days 206 miles. Ex. 100,000 T. 90,000.

BRADNINCH 355 c. 790 l.

- 2 Bradninch in 3 m. 3 p. 9 b. 1 o.
- 1 Broadclist 6 s., 3 m. 1 p. 10 b.
- 2 Tiverton 9 n., 14 m. 48 b. 14 o.
- 1 Stoke 7 s.w., 1 m. 3 p.
- 1 Thorverton 6 s.w., 6 m. 15 b. 1 o.

WELLINGTON 446 c. 1019 l.

- 1 Uffculm 8 s.w., 8 m. 17 b. 1 o.
- 1 Hemycok 7 s., 6 m. 20 b. 1 o.
- 2 Wellington in 15 m. 43 b. 6 o.
- 1 Wiveliscombe 7 n.w., 9 m. 11 b. 5 o.
- 1 Bampton 14 w., 6 m. 16 b. 1 o.

CREDITON 498 c. 1089 l.

- 1 Moreton 13 s.w., 3 m. 32 b. 6 o.
- 1 Oakhampton 18 w., 8 m. 31 b. 3 o.
- 1 N. Tawton 13 w., 9 m. 20 b. 1 o.
- 2 Crediton in 15 m. 48 b. 6 o.
- 1 Witheridge 12 n., 5 m. 15 b. 1 o.

HONITON 752 c. 1801 l.

- 1 Collumpton 12 n.w., 8 m. 1 p. 13 b. 3 o.
- 1 Honiton in 4 m. 36 b. 8 o.
- 1 Axminster 9 s., 5 m., 22 b. 9 o.
- 1 Colyton 8 s.e., 2 m. 1 p. 20 b. 5 o.
- 1 Sidmouth 9 s., 5 m. 19 b. 10 o.
- 1 Woodbury 14 s.w., 4 m. 15 b. 4 o.

EXETER 831 c. 1957 l.

- 5 Exeter in 27 m. 3 p. 141 b. 69 o.
- 1 Topsham 5 s.e., 4 m. 1 p. 16 b. 4 o.
- 1 Exmouth 10 s.e., 6 m. 21 b. 10 o.

GLOUCESTER.

18 days 183 miles; 10 days 183 miles.
Ex. 80,126 T. 104,630.

CIRENCESTER 428 c. 230 l.

- 1 Cirencester in 8 m. 16 b. 9 o.
- 1 Stratton 1 n.e., 7 m. 15 b. 2 o.
- 1 Ampney 3 s., 8 m. 8 b. 2 o.
- 1 Cricklade 7 s., 5 m. 13 b. 13 o.
- 1 Siddington 2 s.w., 7 m. 11 b. 3 o.
- 1 Northleach 11 n.e., 7 m. 14 b. 4 o.

STROUD 929 c. 535 l.

- 1 Stroud in 7 m. 26 b. 10 o.
- 1 Cainscross 1 s., 8 m. 42 b. 6 o.
- 1 Frampton 9 s., 3 m. 47 b. 7 o.
- 1 Painswick 4 n., 8 m. 25 b. 5 o.

- 1 Chalford 5 s., 11 m. 27 b. 2 o.
- 1 Hampton 6 s.e., 6 m. 31 b. 4 o.
- 1 Tetbury 10 s.e., 6 m. 17 b. 12 o.

CHELTHENHAM 984 c. 596 l.

- 4 Cheltenham in 28 m. 165 b. 60 o.
- 3 Tewkesbury 9 n.w., 19 m. 37 b. 19 o.
- 1 Winchcomb 8 n., 5 m. 1 p. 25 b. 5 o.

GLOUCESTER 715 c. 428 l.

- 4 Gloucester in 16 m. 2 s., 182 b. 45 o.
- 1 Newent 9 w., 8 m. 22 b. 7 o.
- 1 Westbury 10 s.w., 3 m. 23 b. 1 o.

GRANTHAM. (STAMFORD.)

17 days 184 miles; 11 days 184 miles.
Ex. 180,600 T. 133,609.

PETERBORO' 1588 c. 1748 l.

- 2 Peterboro' in 14 m. 53 b. 25 o.
- 1 Thorney 8 s., 2 m. 13 b. 7 o.
- 1 Whittlesea 7 s.e., 5 m. 41 b. 5 o.
- 1 Chife 15 s., 7 m. 1 p. 20 b. 1 o.
- 1 Wansford 8 s., 3 m. 1 p. 16 b. 10 o.

STAMFORD 1470 c. 1590 l.

- 3 Stamford in 24 m. 1 s. 62 b. 23 o.
- 1 Deeping 8 s., 6 m. 20 b. 9 o.
- 1 Bourne 11 s., 5 m. 20 b. 12 o.
- 1 Colsterworth 14 n., 9 m. 26 b. 8 o.

GRANTHAM 1948 c. 1519 l.

- 3 Grantham in 30 m. 1 p. 82 b. 36 o.
- 1 Folkingham 14 s., 5 m. 23 b. 10 o.
- 1 Sleaford 14 s., 10 m. 32 b. 27 o.

BOSTON 2559 c. 3098 l.

- 2 Boston in 2 m. 1 s. 39 b. 23 o.
- 1 Donington 11 s.w., 3 m. 23 b. 15 o.
- 1 Tattershall 14 n.w., 4 m. 15 b. 7 o.
- 1 Fosdike Fen 10 w., 3 m. 10 b. 3 o.
- 1 Spalding 16 s., 3 m. 38 b. 15 o.
- 1 Holbeach 17 s.w., 2 m. 13 b. 15 o.

HALIFAX.

400, 18 days 188 miles; 14 days 124 miles.
Ex. 130,800 T. 157,080.

BRADFORD 4637 c. 1914 l.

- 2 Bradford in 4 m. 1 s. 130 b. 19 o.
- 1 Manchester Rd. 1 w., 5 m. 83 b. 1 o.
- 1 Dudley Hill 3 s.e., 10 m. 53 b. 1 o.
- 1 Shipley 4 n.w., 11 m. 31 b. 1 o.
- 1 Pudsey 5 s., 5 m. 63 b. 2 o.
- 1 Undercliffe 3 s., 8 m. 50 b. 4 o.
- 1 Bingley 6 w., 11 m. 1 p. 20 b. 1 o.
- 1 East Morton 9 n.w., 4 m. 3 p. 16 b.

STEETON 9492 c. 1080 l.

- 1 Steeton in 3 m. 23 b. 9 o.
- 1 Settle 23 n.w., 23 b. 4 o.
- 1 Skipton 7 n.w., 2 m. 1 p. 43 b. 9 o.
- 1 Keighley 3 s., 4 m. 2 p. 56 b. 8 o.
- 1 Haworth 6 s.w., 1 p. 35 b. 1 o.
- 1 Thornton 10 s.e., 4 m. 33 b.

DEWSBURY 2310 c. 1187 l.

- 2 Dewsbury in 15 m. 139 b. 4 o.
- 2 Mirfield 3 w., 29 m. 37 b. 1 o.
- 1 Mirfield Lane 1 w., 13 m. 38 b. 2 o.
- 1 Birstal 3 n., 13 m. 51 b.
- 1 Adwalton 3 n.e., 14 m. 15 b. 2 o.

HUDDERSFIELD 4259 c. 1855 l.

- 2 Huddersfield in 10 m. 69 b. 11 o.
- 1 Holmfirth 6 s.w., 1 m. 55 b. 3 o.
- 1 Stainland 6 n.w., 1 p. 33 b. 2 o.
- 2 Brighouse 5 n.e., 16 m. 51 b. 2 o.
- 1 Lepton 5 s.e., 8 m. 26 b.
- 1 Lockwood 2 w., 9 m. 29 b. 2 o.

HALIFAX 3182 c. 1390 l.

- 2 Halifax in 8 m. 105 b. 17 o.
- 1 Amblerthorn 2 n.e., 4 m. 36 b. 4 o.
- 1 Cleckheaton 7 s., 11 m. 37 b. 3 o.
- 1 Elland 8 s.e., 8 m. 1 p. 30 b. 1 o.
- 1 Sowerby B. 3 s.w., 6 m. 1 p. 63 b. 2 o.
- 1 Luddenden 4 n.w., 3 m. 1 p. 41 b. 2 o.

HANTS. (PORTSMOUTH.)

400, 25 days 167 miles; 17 days 167 miles.
Ex. 130,000 T. 124,000.

PETERSFIELD 480 c. 414 l.

- 1 Havant 18 s., 10 m. 24 b. 16 o.
- 1 Hambleden 10 s.w., 9 m. 10 b. 8 o.
- 1 Petersfield in 9 m. 13 b. 8 o.
- 1 Haslemere 14 n.e., 4 m. 1 p. 12 b. 2 o.
- 1 Liphook 10 n., 2 m. 3 p. 9 b. 3 o.

GUILDFORD 624 c. 579 l.

- 2 Farnham 10 w., 16 m. 19 b. 14 o.
- 1 Guildford in 7 m. 10 b. 12 o.
- 1 Bramley 4 s., 7 m. 2 p. 13 b. 7 o.
- 1 Godalming 5 s.w., 6 m. 2 p. 15 b. 10 o.

CHICHESTER 618 c. 601 l.

- 1 Midhurst 12 n., 7 m. 1 p. 10 b. 8 o.
- 1 Petworth 14 n.e., 5 m. 23 b. 4 o.
- 2 Chichester in 16 m. 1 p. 23 b. 9 o.
- 1 Fishbourne 2 w., 6 m. 2 b. 5 o.
- 1 Bognor 7 s. 6 m. 10 b. 5 o.

ARUNDEL 553 c. 475 l.

- 1 Pulborough 9 n.e., 7 m. 6 b. 2 o.
- 1 Billingshurst 15 n.e., 6 m. 14 b. 2 o.
- 1 Storrington 9 s. 8 m. 8 b. 3 o.
- 1 Steyning 15 s., 3 m. 8 b. 4 o.
- 1 Worthing 11 s.e., 4 m. 14 b. 19 o.
- 1 Arundel in 5 m. 1 s. 3 b. 4 o.
- 1 Littlehampton 5 s. 5 m. 8 b. 8 o.

PORTSMOUTH 1748 c. 1617 l.

- 3 Portsmouth in 12 m. 1 s. 83 b. 38 o.
- 1 Gosport 2 w., 4 m. 1 s. 13 b. 11 o.
- 1 Fareham 9 n.w., 7 m. 21 b. 5 o.
- 1 Wickham 13 n.w., 6 m. 17 b. 3 o.
- 1 Titchfield 10 w., 6 m. 9 b. 4 o.

HEREFORD.

21 days 220 miles; 9 days 170 miles. Ex.
83,000 T. 98,000.

MONMOUTH 663 c. 617 l.

- 8 Monmouth in 25 m. 1 p. 119 b. 7 o.
- 1 Ragland 3 s.w., 6 m. 16 b. 2 o.
- 1 Coleford 6 s.e., 10 m. 48 b. 7 o.
- 1 Dean 14 n.e., 13 m. 19 b. 9 o.
- 1 Ross 11 n.e., 9 m. 51 b. 12 o.

CHEPSTOW 635 c. 568 l.

- 2 Chepstow in 9 m. 106 b. 16 o.
- 1 Mounton 3 s.w., 4 p. 10 b.
- 1 Usk 14 n.w., 4 m. 48 b. 4 o.

- 1 Alvington 7 n.e., 5 m. 2 p. 26 b. 3 o.
 1 Newnham 17 n.e., 5 m. 56 b. 2 o.
BROMYARD 680 c. 620 l.
 1 Bromyard in 4 m. 35 b. 4 o.
 1 Tenbury 11 n.w., 5 m. 28 b. 2 o.
 1 Leominster 12 w.s.w., 12 m. 50 b. 9 o.
 1 Ledbury 13 s.e., 8 m. 57 b. 5 o.
HEREFORD 686 c. 646 l.
 2 Hereford in 21 m. 71 b. 24 o.
 1 Eign 1 e., 8 m. 30 b.
 1 Cobhall 5 s.w., 7 m. 17 b.
 1 Madley 7 w., 10 m. 16 b.
 1 New Inn 11 s., 8 m. 17 b.
 1 Weobley 13 n.w., 5 m. 22 b.

There are 1400 hop-planters in this collection not included in the above scheme, requiring, during the season, 8 hop supervisors and 53 officers.

HULL

400, 22 days 290 miles; 10 days 198 miles. Ex. 93,506 T. 111,680.

- HULL**, 1st, 1851 c. 140 l.
 3 Hull in 12 m. 1 p. 2 s. 23 b. 18 o.
 1 Hessel 5 w., 5 m. 6 b. 6 o.
 1 Weighton 20 w., 5 m. 7 b. 4 o.

- HULL**, 2nd, 1752 c. 78 l.
 2 Hull in 9 m. 2 s. 16 b. 14 o.
 1 Hedon 6 e., 3 m. 9 b. 11 o.
 1 Leven 14 n., 4 m. 10 b. 7 o.
 1 Beverley 9 n.w., 9 m. 36 b. 5 o.

- PICKERING** 1486 c. 53 l.
 1 Pickering in 3 m. 1 p. 13 b. 6 o.
 2 Malton 9 s.w., 8 m. 37 b. 13 o.
 1 Kirby 9 w., 1 m. 13 b. 3 o.
 1 Whitby 21 n.e., 3 m. 3 b. 9 o.
 1 Sandsend 26 n.e., 1 m. 7 b.

- BRIDLINGTON** 1523 c. 66 l.
 1 Bridlington in 5 m. 1 s. 12 b. 20 o.
 2 Scarborough 18 n.w., 11 m. 31 b. 54 o.
 2 Driffield 13 s., 10 m. 19 b. 10 o.

ISLE OF WIGHT. (SOUTHAMPTON.)

450, clk. 145, 25 days 218 miles; 13 days 218 miles. Ex. 122,000 T. 120,000

- BROCKENHURST** 620 c. 236 l.
 1 Brockenhurst in 5 m. 11 b. 6 o.
 1 Ringwood 13 w., 6 m. 29 b. 5 o.
 1 Christchurch 13 w., 6 m. 20 b. 5 o.
 1 Lymington 5 s., 4 m. 17 b. 8 o.
 1 Eling 10 e., 6 m. 1 s. 6 b. 3 o.
 1 Beaulieu 9 s.e., 4 m. 9 b. 4 o.

- NEWPORT** 745 c. 385 l.
 2 Newport in 17 m. 23 b. 40 o.
 1 Wellow 9 w., 6 m. 3 b. 8 o.
 1 Ryde 8 e., 1 m. 13 b. 41 o.
 1 Newchurch 7 s.e., 2 m. 4 b. 38 o.

- SOUTHAMPTON** 899 c. 306 l.
 4 Southampton in 16 m. 1 p. 62 b. 78 o.
 2 Romsey 8 n., 18 m. 32 b. 15 o.

- WINCHESTER**, 653 c. 214 l.
 1 Winchester in 10 m. 18 b. 16 o.
 1 St. Cross 1 s., 11 m. 11 b. 3 o.

- 1 Twyford 4 s., 9 m. 12 b. 5 o.
 1 Mitcheldever 8 e., 5 m. 8 b.
 1 Alresford 8 e., 9 m. 12 b. 4 o.
 1 Meorstoke 12 s.e., 8 m. 10 b. 3 o.

ODIHAM 677 c. 232 l.

- 1 Odiham in 9 m. 3 b. 3 o.
 1 Basing 2 n., 9 m. 5 b.
 1 Basingstoke 8 n., 11 m. 7 b. 6 o.
 1 Eversley 9 e., 6 m. 6 b. 8 o.
 2 Alton 8 s., 18 m. 13 b. 6 o.

LANCASTER.

400, 22½ days 229 miles; 20 days 229 miles; 13 days 206 miles. Ex. 118,000 T. 98,000.

LANCASTER 1489 c. 203 l.

- 1 Lancaster in 6 m. 1 s. 73 b. 8 o.
 1 Skerton 1 w., 7 m. 49 b. 3 o.
 1 Low Bentham 15 s.w., 8 m. 49 b. 8 o.
 1 Bolton-le-Sands 4 n.w., 8 m. 42 b. 5 o.
 1 Garstang 11 s., 2 m. 2 p. 26 b. 2 o.
 1 Eccleston 17 s., 3 m. 24 b.

PRESTON 3054 c. 458 l.

- 4 Preston in 16 m. 2 s. 390 b. 17 o.
 1 Kirkham 9 w., 4 m. 39 b. 6 o.
 1 Fleetwood 26 w., 1 m. 27 b. 36 o.

KENDAL 1200 c. 148 l.

- 2 Kendal in 9 m. 2 p. 72 b. 9 o.
 1 Underbarrow 4 w. 8 m. 13 b. 4 o.
 1 Burton 11 s., 6 m. 30 b. 8 o.
 1 Sedbergh 11 e., 3 m. 14 b. 4 o.
 1 Milnthorpe 8 s.w., 7 m. 1 p. 20 b 18 o.

ULVERSTON 1036 c. 162 l.

- 1 Ulverston in 5 m. 1 p. 27 b. 8 o.
 1 Lowick Bridge 6 n., 5 m. 15 b.
 1 Bardsea 3 e., 9 m. 5 b.
 1 Dalton 5 s., 8 m. 8 b. 7 o.
 1 Broughton 10 n. 6 m. 16 b. 2 o.
 1 Hawkshead 16 n., 1 m. 22 b. 20 o.
 1 Carl 12 s., 4 m. 31 b. 7 o.

LEEDS.

450, 7 days 58 miles; 11 days 96 miles. Ex. 362,389 T. 110,000.

BARNESLEY 1607 c. 870 l.

- 1 Barnesley in 2 m. 24 b. 12 o.
 1 Haigh 3 n.w., 7 m. 20 b.
 1 Burton 3 n.e., 7 m. 29 b.
 1 Ecclesfield 6 s., 2 p. 14 b. 3 o.
 1 Wath 7 s.e., 8 m. 13 b. 3 o.
 1 Worsbroadale 3 s., 3 m. 1 p. 20 b. 1 o.
 1 Penistone 7 s.w., 3 m. 19 b. 1 o.

WAKEFIELD, 1st, 613 c. 228 l.

- 1 Thornes 2 w., 1 s. 2 b.
 5 Wakefield in 62 m. 70 b. 2 o.
 1 Sandal 2 s., 10 m. 19 b.

WAKEFIELD, 2nd, 967 c. 420 l.

- 8 Wakefield in 34 m. 65 b. 16 o.
 1 Oulton 6 n., 12 m. 1 p. 18 b.
 1 Lofthouse 4 n., 8 m. 34 b.
 1 Horbury 4 s.w., 8 m. 52 b.

LEEDS, 1st, 2074 c. 986 l.

- 5 Leeds in 23 m. 2 s. 232 b. 26 o.

1 Kirkstall 8 w.w., 15 m. 86 b. 1 o.
 1 Woodside 4 w., 1 m. 2 p. 11 b. 8 o.
LEEDS, 2nd, 1896 c. 693 l.
 2 Leeds 2 n., 18 m. 1 p. 65 b. 2 e.
 2 Hunslet in 17 m. 1 p. 61 b. 3 o.
 1 Holbeck 3 w.w., 18 m. 88 b.
 1 Armley 5 w., 14 m. 19 b.
 1 Wortley 5 w., 5 m. 85 b.

LEEDS, 3rd, 1879 c. 751 l.
 3 Leeds in 19 m. 1 s. 107 b. 28 o.
 1 Otley 11 n.w., 6 m. 1 p. 25 b. 4 o.
 1 Pool 10 n.w., 2 m. 2 p. 9 b. 1 o.
 1 Guiseley 10 n.w., 6 m. 31 b. 7 o.
 1 Thornier 9 n.e., 9 m. 19 b. 2 o.
 1 Woodside 6 n., 2 m. 2 p. 24 b. 1 o.

LEICESTER.

13 days 137 miles; 7 days 109 miles.
 Ex. 120,000 T. 123,000.

HINCKLEY 470 c. 534 l.

1 Lutterworth 11 s.e., 8 m. 85 b. 9 o.
 1 Gilmorton 14 s.e., 8 m. 28 b.
 2 Hinckley in 14 m. 55 b. 11 o.
 1 Earl Shilton 4 n.e., 8 m. 41 b.
 1 Market Bosworth 8 n., 7 m. 21 b. 4 o.
 1 Barlestone 9 n., 8 m. 22 b. 5 o.

LOUGHBOROUGH 718 c. 763 l.

1 Measham 15 w.s.w., 8 m. 33 b. 1 o.
 1 Ashby, 12 w., 4 m. 51 b. 8 o.
 2 Loughborough in 20 m. 95 b. 10 o.
 1 Sheepshed 6 w., 6 m. 35 b. 3 o.
 1 Mountsorrell 4 s.e., 7 m. 48 b.

MELTON MOWBRAY 620 c. 659 l.

1 Stathern 9 n., 6 m. 40 b. 1 o.
 1 Melton in 10 m. 64 b. 9 o.
 1 South Croxton 9 s.w., 6 m. 67 b. 2 o.
 1 Oakham 10 s.e., 8 m. 1 s. 29 b. 8 o.
 1 Uppingham 16 s.s.e., 10 m. 85 b. 5 o.

LEICESTER 975 c. 1023 l.

5 Leicester in 35 m. 1 s. 345 b. 48 o.
 1 Glenfield 4 n.w., 7 m. 90 b.
 1 Wigston 5 s.s.e., 8 m. 41 b.

LICHFIELD.

12 days 91 miles; 9 days 91 miles. Ex.
 130,000 T. not returned.

LICHFIELD 1348 c. 1316 l.

2 Lichfield in 21 m. 105 b. 12 o.
 2 Tamworth 8 s.e., 9 m. 2 p. 38 b. 8 o.
 1 Fazley 8 s.e., 9 m. 30 b. 2 o.
 1 Burton 8 n.e., 11 m. 24 b. 1 o.

BILSTON 1171 c. 928 l.

2 Bilston in 12 m. 222 b. 6 o.
 1 Willenhall 2 n.w., 6 m. 190 b. 3 o.
 1 Bloomfield 3 8 m. 1 s. 41 b. 1 o.
 1 Sedgley 4 s., 11 m. 35 b. 1 o.
 1 Tipton 3 s.e., 8 m. 110 b. 1 o.

WEDNESBURY 1053 c. 950 l.

1 Wednesbury in 6 m. 59 b. 5 o.
 1 Darlaston 2 n.w., 7 m. 100 b. 4 o.
 1 Hill Top 2 7 m. 104 b. 1 o.
 1 Sea Brook 2 2 m. 1 s. 98 b. 2 o.
 1 West Bromwich 4 s.e., 9 m. 125 b. 8 o.
 1 Croft 4 7 m. 88 b. 1 o.

WALSALL 737 c. 468 l.

3 Walsall in 24 m. 205 b. 12 o.
 1 Woodend 1 12 m. 15 b.
 1 Aldridge 4 n.e., 7 m. 47 b.
 1 Sutton 9 w., 10 m. 28 b. 1 o.

BURTON-ON-TRENT 465 c. 410 l.

5 Burton in 70 m. 41 b. 7 o.
 1 Stapenhill 2 s.e., 9 m. 17 b.
 1 Repton 5 n.e., 12 m. 29 b. 1 o.

LINCOLN.

25 days 275 miles; 13½ days 245 miles.
 Ex. 180,000 T. 155,000.

LINCOLN 888 c. 1756 l.

2 Lincoln in 24 m. 1 s. 42 b. 13 o.
 1 Newport 1 w., 7 m. 18 b. 2 o.
 1 Navenby 10 s.e., 6 m. 11 b. 5 o.
 1 Market Rasen 11 n.e., 7 m. 28 b. 14 o.

GAINSBORO' 623 c. 1237 l.

2 Gainsboro' in 20 m. 60 b. 7 o.
 1 Marton 6 s., 8 m. 15 b.
 1 West Stockwith 5 n.w., 7 m. 21 b.
 1 Ferry 12 n.w., 11 m. 18 b. 3 o.

BRIGG 940 c. 1811 l.

1 Brigg in 7 m. 26 b. 6 o.
 1 Kirton 10 s.w., 5 m. 23 b. 3 o.
 1 Winterton 10 n., 13 m. 13 b.
 1 Barton 12 n., 12 m. 13 b. 6 o.
 1 Calster 10 s.e., 4 m. 21 b. 10 o.
 1 Grimsby 21 s., 7 m. 12 b. 16 o.

LOUTH 1106 c. 2210 l.

2 Louth in 13 m. 1 s. 30 b. 12 o.
 9 North Thorsby 10 w., 6 m. 18 b.
 1 Alford 15 s.e., 7 m. 18 b. 6 o.
 1 Burgh 21 s.e., 4 m. 21 b. 12 o.
 1 Spilsby 17 s., 8 m. 1 s. 25 b. 5 o.
 1 Horncastle 13 s.w., 7 m. 84 b. 11 o.

NEWARK 173 c. 1354 l.

5 Newark in 68 m. 95 b. 8 o.
 1 Broughton 8 e., 5 m., 27, b. 2 o.
 1 Balderton 2 s., 10 m. 28 b.

LIVERPOOL.

550, 1st cl. 180, 2nd 160, 3rd 130; 4 days
 50 miles; 2 days 22 miles. Ex. 533,590
 T. 199,670.

LIVERPOOL, 1st., 1608 c. 504 l.

5 Liverpool in 4 s. 13 b. 87 o.

LIVERPOOL, 2nd, 960 c. 118 l.

5 Liverpool in 5 s. 8 b. 28 o.

LIVERPOOL, 3rd, 1235 c. 269 l.

3 Liverpool in 6 s. 11 b. 4 o.
 2 Birkenhead 3 w., 1 s. 13 b. 63 o.

LIVERPOOL, 4th, 1085 c. 236 l.

4 Liverpool in 5 s. 10 b. 19 o.
 1 Woolton 6 s.e., 3 m. 13 b. 27 o.

LIVERPOOL, 5th, 2113 c. 501 l.

6 Liverpool in 1 d. 4 m. 2 s. 38 b. 180 o.
 1 Kirkdale 3 n., 1 m. 15 b. 90 o.

PORT DEPARTMENT.

1 Port Surveyor 3004; 1 Assistant
 Exp. Sur. 2004; 1 Assistant Im-
 port Surveyor 2004; 1 Warehouse

keeper 120l.; 1 Sample drawer 65l.; 1st Exp. clerk 140l.; 2nd 120l.; 7 Exp. officers 100l. each; 1 Port Gauger 120l.; 2 Imp. officers 90l. each; 3 Rummaging officers 100l. each; 3 Rummaging officers' assistants 3s. 6d. per day.

In this Collection there are also 22 Assistants and 3 Permit-writers.

LONDON, EAST.

450, 2nd and 3rd clk 120, Ex. 1,187,628, exclusive of import duties, and duties on goods relanded.

LONDON, EAST, 45 c. 1752 l.

12 London East in 4 s. 11 b. 25 o.

RATCLIFF 26 c. 1648 l.

14 Ratcliff in 6s. 9 b. 14 o.

STEPNEY 52 c. 3154 l.

18 Stepney in 1 d. 1 m. 1 p. 1 s. 8 b. 54 o.

HOXTON 56 c. 2046 l.

15 Hoxton in 5 s. 5 b. 27 o.

HACKNEY 70 c. 2472 l.

11 Hackney in 2 m. 3 s. 8 b. 48 o.

In this collection there are 4 Permit writers, and the port establishment may be considered as included within it. See list in p. 230.

LONDON, NORTH.

450, 2nd and 3rd clk 120. Ex. 500,000.

MARYLEBONE 1261 c. 1510 l.

5 Marylebone in 1 s. 8 b. 148 o.

HOLBORN 1531 c. 1460 l.

5 Holborn in 3 p. 2 s. 5 b. 118 o.

ISLINGTON 1512 c. 1006 l.

5 Islington in 3 s. 20 b. 109 o.

LONDON, NORTH, 1st, 954 c. 1807 l.

5 London n., in 5 p. 1 b. 64 o.

LONDON, NORTH, 2nd, 1083 c. 1020 l.

5 London n., in 6 p. 2 s. 4 b. 81 o.

LONDON, SOUTH.

450, 2nd and 3rd clks. 120. Ex. 900,000.

MILBANK 1234 c. 1410 l.

5 Milbank in 1 d. 2 m. 18 b. 94 o.

WESTMINSTER 1598 c. 1886 l.

6 Westminster in 2 b. 155 o.

SOUTHWARK 1368 c. 1175 l.

5 Southwark in 1 p. 4 s. 9 b. 78 o.

LAMBETH, 1st, 1099 c. 876 l.

5 Lambeth in 2 p. 3 s. 25 b. 59 o.

LAMBETH, 2nd, 1297 c. 680 l.

5 Lambeth in 5 m. 6 s. 19 b. 79 o.

LYNN.

20 days 220 miles; 15 days 220 miles. Ex. 137,000 T. 149,000.

WELLS 765 c. 435 l.

1 Wells in 11 m. 8 b. 15 o.

1 Fakenham 10 s., 4 m. 18 b. 15 o.
1 Overy Staith 6 8 m. 16 b. 11 o.
1 Holt 12 s.s.s., 4 m. 1 p. 6 b. 5 o.
1 Brinton 10 s.s., 3 m. 1 s. 7 b. 1 o.
1 Clay 10 s., 9 m. 3 b. 4 o.

DEREHAM 983 c. 540 l.

1 Dereham in 7 m. 9 b. 11 o.
1 Brisley 7 s., 4 m. 3 b. 1 o.
1 Beepham 11 s.s., 3 m. 1 p. 2 b. 6 o.
1 Hingham 10 s.s.s., 2 m. 6 b. 15 o.
1 Swaffham 18 w.s.w., 3 m. 6 b. 10 o.
1 Narbore 19 w., 6 m. 3 b.

THETFORD 674 c. 352 l.

2 Thetford in 16 m. 1 p. 16 b. 10 o.
1 Mildenhall 12 s.w., 7 m. 18 b. 14 o.
1 Diss 18 s.w., 14 m. 6 b. 10 o.
1 Kenninghall 13 s., 5 m. 2 b. 9 o.
1 Brandon 7 w.s.w., 5 m. 14 b. 4 o.

LYNN 1410 c. 701 l.

2 Lynn in 18 m. 1 p. 23 b. 29 o.
1 Wisbeach 14 s.w., 2 m. 16 b. 26 o.
1 Downham 12 s., 3 m. 4 b. 14 o.
1 Grimstone 6 s.s.s., 3 m. 7 b. 5 o.
1 Stoke 15 s.s.s., 10 m. 4 b. 40.

MANCHESTER.

450, 2nd clk. 1382 10s. 11 days 99 miles; 6 days 99 miles. Ex. not returned. T. not returned.

MANCHESTER, 1st, 3996 c. 680 l.

1 Manchester in 19 b. 8 o.
1 Gorton Brook 3 s., 1 s. 8 b.
1 Ardwick 2 s., 39 b. 6 o.
1 Longsight 2 s., 50 b. 7 o.
1 Stockport 6 s., 67 b. 9 o.
1 Heavily 7 s., 84 b. 11 o.
1 Heaton 6 s., 1 p. 25 b. 3 o.

MANCHESTER, 2nd, 4441 c. 675

1 Oldham Road in 1 s. 20 b.
1 Parsonage 2 s., 16 b. 9 o.
1 Shudehill 1 s., 19 b. 4 o.
1 Collyhurst 2 s., 1 p. 1 s. 27 b.
1 Redbank 1 s., 41 b. 19 o.
1 Harpur-hey 3 s., 1 p. 97 b. 1 o.
1 Failsworth 3 s., 92 b. 1 o.

MANCHESTER, 3rd, 3887 c. 635 l.

2 Salford 2 w., 1 s. 49 b. 12 o.
1 Hedgecroft 6 w., 1 s. 4 b.
1 Eccles 5 w., 46 b. 5 o.
2 Hulme in 48 b. 24 o.
1 Throstlenest 3 s., 1 p. 21 b. 4 o.

ASHTON 4079 c. 480 l.

1 Ashton in 183 b. 6 o.
1 Staleybridge 2 s., 157 b. 4 o.
1 Hyde 4 w., 168 b. 4 o.
1 Dobcross 9 s., 1 p. 75 b. 2 o.
2 Charlestown 9 s., 2 p. 105 b. 5 o.

ROCHDALE 3735 c. 569 l.

1 Oldham 6 s., 144 b. 2 o.
1 Mumps 6 s., 136 b. 4 o.
1 Moss 1 s., 175 b. 5 o.
1 Bacup 8 s., 123 b. 15 o.
1 Milnson 3 s., 116 b. 5 o.
1 Rochdale in 167 b. 6 o.

MIDDLESEX.

400, clk. 145, 16 days 254 miles; 13 days 236 miles. Ex. 1,100,000 T. 100,000.

HARLOW 669 c. 299 l.

- 1 Harlow in 7 m. 6 b. 6 o.
- 2 Sawbridgeworth 8 n., 21 m. 7 b. 2 o.
- 1 Ongar 10 n., 3 m. 9 b. 8 o.
- 1 Epping 7 w., 3 m. 5 b. 15 o.
- 1 Waltham 12 s., 2 m. 11 b. 20 o.

WEST HAM 1123 c. 890 l.

- 1 Edmonton 9 w., 1 m. 11 b. 33 o.
- 1 Romford 10 n., 5 m. 5 b. 14 o.
- 1 Ilford 4 w., 1 m. 5 b. 37 o.
- 1 West Ham in 1 d. 3 b. 18 o.

BILLERICAY 667 c. 385 l.

- 1 Grays 15 n., 3 m. 2 b. 7 o.
- 1 Rayleigh 11 n.e., 2 m. 5 b. 7 o.
- 1 Rochford 17 n.e., 1 m. 13 b. 15 o.
- 1 Billericay in 3 m. 3 b. 5 o.
- 1 Brentwood 6 w., 4 m. 12 b. 12 o.

UXBRIDGE 601 c. 241 l.

- 1 Uxbridge in 2 m. 5 b. 22 o.
- 1 West Drayton 4 e., 3 m. 2 p. 1 b. 5 o.
- 1 Amersham 11 n. 4 m. 2 p. 3 b. 12 o.
- 2 Rickmansworth 8 n.w., 5 m. 4 p. 3 b. 9 o.

BROMLEY 194 c. 155 l.

- 3 Bromley in 2 d. 7 m. 2 p. 3 b. 18 o.

CAMDEN TOWN 2273 c. 1496 l.

- 1 Barnet 12 n., 1 m. 15 b. 22 o.
- 2 Camden Town in 7 b. 51 o.
- 2 Paddington 4 w., 3 b. 85 o.
- 1 Hampstead 5 w., 2 b. 23 o.
- 1 Kilburn 5 n.w., 2 m. 3 b. 26 o.

NEWCASTLE.

450, 19 days 259 miles; 11 days 227 miles. Ex. 260,000 T. 110,000.

NEWCASTLE-ON-TYNE 2596 c. 204 l.

- 9 Newcastle in 1 d. 25 m. 1 s. 87 b. 36 o.

SOUTH SHIELDS 3792 c. 148 l.

- 1 South Shields in 4 m. 1 s. 9 b. 2 o.
- 2 North Shields 2 n., 8 m. 14 b. 10 o.
- 1 Jarrow 5 w., 1 m. 2 p. 6 b. 2 o.
- 1 Blyth 12 n., 2 m. 3 b. 4 o.
- 2 Morpeth 18 n., 9 m. 10 b. 7 o.

ALNWICK 2062 c. 74 l.

- 2 Alnwick in 8 m. 12 b. 11 o.
- 1 Rothbury 12 s.w., 3 m. 5 b. 5 o.
- 1 Wooler 18 n.w., 1 m. 1 b. 6 o.
- 1 Berwick 30 n., 6 m. 3 b. 9 o.
- 1 Belford 15 n., 2 m. 2 b. 7 p.

HEXHAM 1684 c. 64 l.

- 2 Hexham in 9 m. 1 p. 12 b. 8 o.
- 1 Wark 12 n., 1 m. 1 p. 3 b. 3 o.
- 1 Wylam 13 e., 5 m. 4 b. 1 o.
- 1 Haltwhistle 16 w., 1 m. 3 b. 2 o.
- 1 Alston 24 s.w., 2 m. 1 b. 5 o.

OTTERBURN BORDER DISTRICT.

- 2 Falstone 14 s.w. } Employed to prevent smuggling from Scotland.
- 2 Rochester 6 n.w. }
- 2 Harbottle 12 n.e. }
- 2 Powburn 25 n. }

NORHAM BORDER DISTRICT.

- 2 Norham in } Employed to prevent smuggling from Scotland.
- 2 Cornhill 8 w. }
- 2 Wooler 18 s. }
- 2 Berwick 6 n. }

NORTHAMPTON.

16 days 175 miles; 9 days 148 miles. Ex. 86,000 T. 115,000.

MARKET-HARBOROUGH 582 c. 295 l.

- 1 Church Langton 4 n.e., 7 m. 48 b. 2 o.
- 1 Welford 9 s.w., 9 m. 34 b. 2 o.
- 1 Harborough in 10 m. 39 b. 10 o.
- 1 Rawell 7 e., 8 m. 34 b. 5 o.
- 1 Kettering 11 s.e., 10 m. 34 b. 14 o.
- 1 Gtretton 14 s.e., 9 m. 28 b. 4 o.

THRAPSTON 615 c. 232 l.

- 1 Oundle 8 n., 10 m. 7 b. 10 o.
- 1 Thrapston in 9 m. 20 b. 6 o.
- 1 Kimbolton 11 s.e., 15 m. 25 b. 3 o.
- 1 Wellingborough 11 s.w., 10 m. 30 b. 7 o.
- 1 Wollaston 13 s.w., 8 m. 30 b. 2 o.
- 1 Irthlingborough 8 s.w., 7 m. 1 p. 34 b. 4 o.

BUCKINGHAM 678 c. 596 l.

- 1 Stony Stratford 8 n., 8 m. 32 b. 6 o.
- 1 Great Harwood 8 s.e., 7 m. 15 b. 1 o.
- 1 Winslow 8 s., 7 m. 17 b. 1 o.
- 2 Buckingham in 14 m. 28 b. 5 o.
- 1 Brackley 9 w., 12 m. 24 b. 2 o.
- 1 Hanstape 13 n., 8 m. 1 p. 24 b.

NORTHAMPTON 1152 c. 848 l.

- 1 Moulton 5 n., 9 m. 36 b. 8 o.
- 1 Wootton 8 s., 8 m. 31 b. 9 o.
- 2 Northampton in 19 m. 1 p. 115 b. 28 o.
- 1 Towcester 9 w., 8 m. 33 b. 12 o.
- 1 Bugbrooke 6 s.w., 7 m. 1 s. 23 b. 3 o.
- 1 Blakesley 14 w., 7 m. 21 b. 4 o.

NORTHWICH. (WARRINGTON.)

400, 17½ days 190 miles; 9½ days 171 miles. Ex. 159,000 T. 126,000.

ORMSKIRK 1306 c. 783 l.

- 1 Ormskirk in 8 m. 27 b. 12 o.
- 1 Tarleton 10 n., 4 m. 23 b. 1 o.
- 2 Chorley 17 n.e., 4 m. 1 p. 91 b. 7 o.

WARRINGTON 917 c. 660 l.

- 3 Warrington in 12 m. 1 s. 66 b. 17 o.
- 1 Mill Bank 9 e.n.e., 1 p. 20 b. 2 o.
- 1 Wilderspool 2 s.e., 3 m. 20 b.
- 1 Altringham 11 s.e., 24 b. 11 o.

RUNCORN 1704 c. 1337 l.

- 2 Runcorn in 3 m. 2 s. 5 b. 4 o.
- 1 Frodsham 6 s., 2 m. 12 b. 3 o.
- 1 Tarporley 19 s., 4 m. 17 b. 7 o.
- 1 Tattenhall 25 s., 2 m. 13 b. 3 o.
- 1 Northwich 12 s.e., 1 m. 23 b. 10 o.
- 1 Winsford Lane 18 s.e., 45 b. 6 o.

MACCLESFIELD 2110 c. 1297 l.

- 2 Macclesfield in 161 b. 15 o.
- 1 Folly Grove 8 .1 p. 52 b. 1 o.
- 2 Congleton 8 s.s.w., 106 b. 12 o.
- 1 Sandbach 15 s.w., 47 b. 8 o.
- 1 Knutsford 12 w.n.w., 39 b. 13 o.

NORWICH.

450, 15 days 225 miles; 9 days 175 miles.
Ex. 410,700 T. 145,180.

NORWICH, 1st, 1288 c. 1063 l.

5 Norwich in 1 r. 37 m. 1 p. 2 s. 25 b. 38 o.

1 Wymondham 10 w.s.w., 7 m. 3 b. 5 o.

NORWICH, 2nd, 1018 c. 621 l.

3 Norwich in 28 m. 5 b. 10 o.

1 Tasburgh 9 s.w., 5 m. 3 b. 1 o.

1 Taverham 6 n.w., 2 m. 1 p. 4 b. 1 o.

1 Blofield 6 e., 8 m. 2 b. 4 o.

COLTISHALL 772 c. 445 l.

2 Coltishall in 18 m. 5 b. 1 o.

1 Aylsham 7 e.n.e., 4 m. 12 b. 12 o.

1 Walsham 7 n.n.e., 7 m. 8 b. 10 o.

1 Tunstead 6 n.e., 6 m. 5 b. 1 o.

1 Ludham 9 w.n.w., 6 m. 4 b. 1 o.

BECCLES 876 c. 573 l.

2 Beccles in 22 m. 13 b. 9 o.

1 Loddon 7 n.w., 5 m. 5 b. 2 o.

1 Harleston 14 e., 4 m. 9 b. 9 o.

1 Bungay 6 n.e., 9 m. 1 p. 8 b. 10 o.

1 Lowestoft 10 w., 7 m. 1 s. 6 b. 16 o.

YARMOUTH 743 c. 599 l.

5 Yarmouth in 51 m. 1 s. 9 b. 16 o.

1 Gorleston 3 s., 14 m. 4 o.

OXFORD.

14 days 202 miles; 11 days 172 miles.
Ex. 104,000 T. 108,000.

DEDDINGTON 749 c. 572 l.

1 Deddington in 7 m. 1 p. 22 b. 6 o.

1 Chipping Norton 11 w., 7 m. 16 b. 12 o.

1 Long Compton 16 n.w., 6 m. 22 b. 1 o.

1 Barton 7 s., 7 m. 27 b. 12 o.

2 Bicester 11 e., 17 m. 48 b. 5 o.

BANBURY 403 c. 394 l.

2 Banbury in 19 m. 38 b. 22 o.

1 N. Newton 4 n.w., 8 m. 2 p. 14 b. 2 o.

1 Warmington 6 w., 10 m. 14 b. 2 o.

1 Middleton 4 n., 12 m. 17 b. 3 o.

1 Bloxham 4 s.w., 10 m. 23 b. 5 o.

SWINDON 587 c. 554 l.

1 Swindon in 7 m. 15 b. 6 o.

1 Farrington 13 e., 6 m. 21 b. 8 o.

1 Lambourn 14 s.e., 8 m. 12 b. 4 o.

1 Wootton Bassett 6 w., 6 m. 18 b. 3 o.

1 Highworth 7 n., 8 m. 11 b. 7 o.

BURFORD 648 c. 549 l.

1 Burford in 7 m. 1 p. 34 b. 9 o.

1 Lichlade 10 s.w., 7 m. 20 b. 4 o.

1 Bampton 8 s., 7 m. 20 b. 6 o.

1 Fairford 11 s.w., 7 m. 1 p. 14 b. 3 o.

1 Witney 8 e., 14 m. 28 b. 12 o.

1 Charlbury 11 n.e., 8 m. 17 b. 5 o.

OXFORD 932 c. 670 l.

3 Oxford in 19 m. 4 p. 30 b. 50 o.

1 Headington 3 e., 6 m. 5 b. 2 o.

1 Kidlington 5 n., 4 m. 1 p. 10 b. 9 o.

1 Eusham 6 w., 8 m. 1 p. 17 b. 1 o.

PLYMOUTH.

400, 18 days 245 miles; 18 days 181 miles.
Ex. not returned T. not returned.

CALLINGTON 932 c. 1513 l.

1 Saltash 10 n., 5 m. 9 b. 5 o.

1 Polbathick 14 n., 3 m. 10 b. 4 o.

1 Liskeard 9 w., 4 m. 1 s. 25 b. 15 o.

1 Callington in 5 m. 2 p. 14 b. 6 o.

1 Tavistock 10 e., 7 m. 29 b. 13 o.

NEWTON ABBOT 1538 c. 2641 l.

1 Totnes 8 s., 6 m. 1 p. 41 b. 10 o.

1 Ashburton 10 w., 4 m. 1 p. 34 b. 13 o.

1 Chudleigh 6 n., 2 m. 18 b. 6 o.

1 Newton in 9 m. 1 p. 35 b. 7 o.

1 Teignmouth 6 e., 5 m. 32 b. 19 o.

1 Torquay 7 s.e., 4 m. 27 b. 30 o.

1 Dartmouth 16 s., 5 m. 50 b. 13 o.

MODBURY 612 c. 1049 l.

2 Kingsbridge 8 s.e., 20 m. 40 b. 5 o.

1 Frogmore 12 s.e., 7 m. 26 b.

1 Modbury in 8 m. 17 b. 1 o.

1 Antongifford 4 s., 8 m. 10 b. 1 o.

1 Plympton 10 n.w., 5 m. 1 p. 16 b. 6 o.

1 Ivybridge 5 n., 3 m. 2 p. 7 b. 2 o.

PLYMOUTH 1654 c. 3164 l.

2 Devonport 3 w., 12 m. 32 b. 23 o.

4 Plymouth in 17 m. 3 s. 62 b. 45 o.

1 Plymouth port in.

1 Plymouth permit office.

READING.

20 days 177 miles; 14 days 154 miles.
Ex. 161,716 T. 132,000.

WINDSOR 1322 c. 1450 l.

2 Windsor in 6 m. 7 b. 28 o.

1 Slough 3 n., 3 m. 3 b. 17 o.

1 Maldenhead 6 n.w., 2 m. 2 p. 3 b. 12 o.

2 Cookham 9 n.w., 4 m. 5 p. 1 o.

1 Colnbrook 5 e., 3 p. 2 b. 5 o.

HENLEY ON THAMES 1552 c. 1616 l.

8 Henley in 16 m. 1 p. 5 b. 11 o.

2 Marlow 8 n.e., 7 m. 2 p. 3 b. 3 o.

1 Watlington 11 n.w., 2 m. 2 b. 4 o.

1 Benson 11 w.n.w., 4 m. 1 s. 3 o.

1 Wallingford 11 w.n.w., 9 m. 2 b. 7 o.

ABINGDON 1285 c. 1286 l.

2 Abingdon in 14 m. 22 b. 14 o.

1 Dorchester 8 s.e., 10 m. 5 b. 1 o.

1 Wantage 10 s.w., 7 m. 17 b. 9 o.

1 Harwell 7 s., 8 m. 11 b. 2 o.

1 Hagbourn 8 s.e., 3 m. 1 p. 4 b. 1 o.

1 Sutton 3 s.s.w., 3 m. 1 p. 3 b. 2 o.

NEWBURY 1157 c. 1229 l.

2 Newbury in 19 m. 18 b. 19 o.

1 Kingsclere 7 s.e., 6 m. 3 b. 1 o.

1 Donnington 2 n., 6 m. 1 p. 6 b.

1 Newbury Wash 2 s., 7 m. 12 b.

1 Aldermaston 9 e., 6 m. 3 b. 3 o.

1 Thatcham 4 e., 2 m. 1 p. 1 b. 1 o.

READING 1979 c. 2067 l.

3 Reading in 14 m. 1 p. 23 b. 36 o.

1 Wokingham 7 e.s.e., 5 m. 6 b. 9 o.

2 Theale 5 w.s.w., 4 m. 1 p. 6 b. 3 o.

1 Pangbourn 6 w.n.w., 5 m. 2 b. 3 o.

ROCHESTER. (MAIDSTONE.)

450, 17 days 187 miles; 11 days 196 miles;
19 days 208 miles. Ex. 298,760 T. 105,356.

MAIDSTONE 1521 c. 256 l.

- 3 Maidstone in 11 m. 6 p. 15 b. 21 o.
- 1 Loose 4 s., 2 m. 4 p. 4 b. 2 o.
- 1 Hadlow 11 s.w., 3 m. 1 p. 2 b. 2 o.
- 1 Tunbridge 14 s.w., 3 m. 5 b. 11 o.
- 1 Lenham 10 s.e., 3 m. 1 p. 2 o.

ROCHESTER 2645 c. 258 l.

- 1 Rochester in 2 m. 6 b. 30 o.
- 1 Chatham 2 s., 4 m. 4 b. 11 o.
- 1 Frindsbury 2 s.w., 1 m. 1 p. 2 b. 5 o.
- 1 Milton 11 s.e., 5 m. 1 p. 3 b. 14 o.
- 1 Sheerness 21 s.w., 1 b. 12 o.
- 1 Malling 10 s.w., 8 m. 2 p. 4 b. 11 o.
- 1 Wrotham 14 s.w., 3 m. 1 p. 3 b. 3 o.

DEPTFORD 3834 c. 331 l.

- 1 Woolwich 5 s., 1 m. 2 b. 19 o.
- 3 Deptford in 3 m. 2 s. 3 b. 30 o.
- 1 Camberwell 4 w., 1 s. 17 b. 16 o.
- 1 Greenwich 2 s., 1 m. 8 b. 61 o.

ST. MARY CRAY 2187 c. 249 l.

- 1 Gravesend 14 s.e., 3 b. 18 o.
- 2 Dartford 8 s.w., 5 m. 4 p. 11 b. 18 o.
- 1 St. Mary Cray in 1 m. 1 p. 1 b.
- 1 St. Paul's Cray 1 s.w., 2 m. 2 p. 6 b. 13 o.
- 1 Eynsford 6 s.e., 6 m. 2 p. 2 b. 1 o.
- 1 Westerham 12 s., 4 m. 1 p. 8 b. 14 o.

SALOP. (SHREWSBURY.)

400, 11 days 157 miles; 9 days 111 miles.
Ex. 75,000 T. 60,000.

SALOP, 2nd, 708 c. 213 l.

- 2 Shrewsbury in 25 m. 70 b. 35 o.
- 1 Church Stretton 14 s., 10 m. 24 b. 5 o.
- 1 Dorrington 7 s., 9 m. 12 b. 1 o.
- 1 Pontesbury 8 s.w., 7 m. 26 b. 4 o.
- 1 Ford 7 w., 7 m. 14 b. 6 o.

IRONBRIDGE 696 c. 224 l.

- 2 Ironbridge in 18 m. 63 b. 18 o.
- 1 Much Wenlock 5 s.w., 10 m. 28 b. 13 o.
- 1 Hungerford 16 s., 8 m. 15 b.
- 1 Broseley 2 s., 8 m. 26 b. 9 o.
- 1 Madeley 2 s., 9 m. 37 b. 5 o.

WELLINGTON 852 c. 320 l.

- 2 Wellington in 20 m. 62 b. 19 o.
- 2 Shiffnal 8 s.e., 21 m. 30 b. 10 o.
- 1 Ketley 3 s., 7 m. 57 b. 4 o.
- 1 Dawley Green 4 s.e., 8 m. 42 b. 2 o.
- 1 Hadley 8 s.e., 10 m. 26 b. 3 o.

SALOP, 1st, 576 c. 168 l.

- 3 Shrewsbury in 27 m. 79 b. 19 o.
- 1 Roden 7 s.e., 8 m. 9 b. 2 o.
- 1 Atcham 4 s.e., 6 m. 14 b. 3 o.
- 1 Allscott 10 s., 7 m. 11 b. 1 o.

NEWPORT 569 c. 181 l.

- 2 Newport in 24 m. 43 b. 14 o.
- 1 Eccleshall 9 s.e., 10 m. 22 b. 10 o.
- 1 Bishop's Cleeve 9 s., 8 m. 21 b. 1 o.
- 1 Hinstock 6 s.w., 12 m. 9 b. 1 o.
- 1 Edgmond 2 s., 8 m. 1 p. 10 b. 3 o.
- 1 Gnosall 7 s.e., 9 m. 16 b. 2 o.

SARUM. (SALISBURY.)

17 days 171 miles; 11 days 149 miles.
Ex. 90,000 T. 88,000.

DEVIZES 945 c. 918 l.

- 2 Devizes in 13 m. 38 b. 17 o.
- 1 Marden 7 s.e., 7 m. 15 b. 3 o.
- 1 Lavington 6 s., 7 m. 18 b. 1 o.
- 1 Tilshead 11 s.e., 5 m. 14 b. 1 o.
- 1 Netheravon 16 s.e., 6 m. 1 p. 17 b. 3 o.

MARLBOROUGH 988 c. 915 l.

- 2 Marlboro' in 19 m. 42 b. 8 o.
- 2 Hungerford 10 s., 18 m. 29 b. 10 o.
- 1 Pewsey 7 s.w., 5 m. 14 b. 6 o.
- 1 Burghage 6 s.w., 9 m. 10 b.

SARUM 1173 c. 1146 l.

- 3 Sarum in 23 m. 69 b. 22 o.
- 1 Fordingbridge 12 s., 7 m. 16 b. 4 o.
- 1 Downton 7 s.e., 6 m. 1 p. 17 b.
- 1 Wilton 4 w., 9 m. 21 b. 3 o.
- 1 West Dean 8 s., 6 m. 14 b. 30 o.

ANDOVER 1061 c. 1069 l.

- 1 Andover in 6 m. 23 b. 12 o.
- 1 Broughton 11 s.w., 11 m. 17 b. 2 o.
- 1 Whitchurch 7 s.e., 6 m. 1 p. 14 b. 3 o.
- 1 Uphurstbourne 6 w., 10 m. 13 b.
- 1 Overton 11 s.e., 8 m. 1 p. 9 b. 2 o.
- 1 Wherwell 4 s.e., 9 m. 17 p. 3 o.
- 1 Mullenspond 5 w., 8 m. 24 b. 3 o.

SHEFFIELD.

19½ days 159 miles; 12 days 166 miles.
Ex. 131,300 T. 113,681.

SHEFFIELD 2370 c. 1869 l.

- 4 Sheffield in 24 m. 1 s. 85 b. 52 o.
- 1 Wicker and P. 1 s. 6 m. 23 b. 3 o.
- 1 Owlerton 3 s.w., 2 m. 5 p. 17 b. 1 o.
- 2 Rotherham 6 s.e., 13 m. 1 s. 7 b. 9 o.

CHAPEL-EN-LE-FRITH 875 c. 621 l.

- 1 Chapel in 1 p. 33 b. 4 o.
- 1 New Mills 6 s.w., 1 p. 55 b. 10 o.
- 1 Buxton 6 s., 25 b. 20 o.
- 1 Bakewell 17 s.e., 42 b. 12 o.
- 1 Baslow 18 s.e., 1 m. 41 b. 11 o.
- 1 Tideswell 9 s., 1 p. 36 b. 12 o.

CHESTERFIELD 698 c. 671 l.

- 2 Chesterfield in 22 m. 72 b. 15 o.
- 1 Woodhouse 13 s.w., 5 m. 19 b.
- 1 Claycross 5 s., 6 m. 39 b. 3 o.
- 1 Bolsover 7 s., 6 m. 33 b. 2 o.
- 1 Eckington 6 s.e., 6 m. 23 b. 1 o.
- 1 Dronfield 6 s.w., 5 m. 25 b. 2 o.

RETTFORD 530 c. 377 l.

- 2 Retford in 11 m. 2 p. 3 b. 59 b. 9 o.
- 1 Sutton 12 s.w., 9 m. 21 b. 24 b. 2 o.
- 1 Ollerton 12 s.w., 5 m. 30 b. 31 b. 4 o.
- 1 Laneham 10 s.e., 9 m. 11 h. 21 b.
- 1 Tuxford 7 s.e., 8 m. 6 h. 27 b. 2 o.

WORKSOP 451 c. 337 l.

- 3 Worksop in 40 m. 32 b. 11 o.
- 1 Whitwell 5 s.w., 8 m. 43 b. 1 o.
- 1 South Anston 6 s.w., 11 m. 31 b. 1 o.
- 1 Blyth 7 s.e., 9 m. 25 b. 1 o.

STAFFORD.

17 days 182 miles; 12 days 143 miles;
20 days 171 miles. Ex. 64,000 T.
88,000.

NEWCASTLE-UNDER-LYNE 825 c.

- 3 Newcastle in 19 m. 1 p. 141 b. 12 o.
- 1 Flash 4 s.e., 7 m. 20 b. 2 o.
- 1 Burslem 4 n.w., 2 m. 72 b. 7 o.
- 1 Tunstall 5 n.w., 2 m. 75 b. 6 o.

HANLEY 1255 c. 1159 l.

- 1 Hanley in 3 m. 1 p. 99 b. 4 o.
- 1 Bucknall 1 e., 1 m. 82 b. 5 o.
- 1 Longton 3 s.e., 9 m. 65 b. 3 o.
- 1 Stoke 2 s.w., 5 m. 64 b. 6 o.
- 1 Mear Green 4 s.e., 3 m. 87 b. 15 o.
- 1 Leek 9 n.e., 2 m. 1 p. 69 b. 8 o.

UTTOXETER 761 c. 625 l.

- 1 Cheadle 10 n.w., 7 m. 30 b. 7 o.
- 1 Alton 8 n.w., 1 m. 1 p. 31 b. 5 o.
- 1 Upper Tean 8 n.w., 5 m. 45 b. 6 o.
- 1 Winkhill 16 n.w., 1 m. 1 p. 37 b. 3 o.
- 1 Uttoxeter in 9 m. 35 b. 9 o.
- 1 Heath 2 w., 4 m. 27 b. 1 o.
- 1 Abbott's Bromley 7 s., 6 m. 20 b. 2 o.
- 1 Tutbury 10 s.e., 7 m. 24 b.

PENKRIDGE 395 c. 330 l.

- 1 Rugeley 9 n.e., 10 m. 89 b. 4 o.
- 1 Armitage 13 e., 6 m. 21 b. 1 o.
- 1 Penkridge in 5 m. 23 b. 2 o.
- 1 Cannock 5 s.e., 6 m. 88 b. 1 o.
- 1 Brewood 5 s.w., 10 m. 16 b. 2 o.
- 1 Shavesbill 7 s.e., 10 m. 15 b.
- 1 Wheaton Aston 6 w.s.w., 11 m. 14 b. 1 o.

STAFFORD 590 c. 467 l.

- 2 Stone 7 n., 10 m. 44 b. 3 o.
- 1 Sandon 6 n.w., 8 m. 14 b. 1 o.
- 2 Stafford in 16 m. 86 b. 9 o.
- 1 Haughton 6 s.w., 7 m. 16 b.
- 1 Haywood 7 n., 8 m. 16 b. 3 o.

STOURBRIDGE

400, 16 days 159 miles; 11 days 108 miles;
Ex. 191,906 T. 83,498.

BRIDGNORTH 272 c. 224 l.

- 4 Bridgnorth in 39 m. 117 b. 13 o.
- 1 Claverly 6 s.e., 9 m. 20 b.
- 1 Albrighton 12 n.e., 11 m. 14 b. 1 o.

WOLVERHAMPTON 683 c. 321 l.

- 4 Wolverhampton in 42 m. 345 b. 24 o.
- 1 Tettenhall 2 n.w., 13 m. 33 b. 3 o.
- 1 Wombourne 5 s., 11 m. 24 b.

DUDLEY 878 c. 599 l.

- 4 Dudley in 42 m. 294 b. 13 o.
- 1 Shaver's End 1 n.w., 10 m. 68 b.
- 1 Kingswinford 4 n.w., 10 m. 48 b.

BEWDLEY 1067 c. 991 l.

- 2 Bewdley in 19 m. 76 b. 7 o.
- 3 Kidderminster 3 e., 29 m. 1 p. 154 b. 29 o.
- 1 Stourport 4 s., 7 m. 43 b. 4 o.
- 1 Kinver 8 n.e., 11 m. 30 b. 10 o.

LUDLOW 453 c. 523 l.

- 2 Ludlow in 21 m. 1 p. 80 b. 10 o.
- 1 Newton 8 n.w., 3 m. 20 b. 1 o.
- 1 Aymestry 12 s.w., 9 m. 25 b. 1 o.
- 1 Cleobury 11 n.e., 11 m. 2 p. 36 b. 3 o.

STOURBRIDGE 573 c. 252 l.

- 2 Stourbridge in 20 m. 107 b. 14 o.
- 1 Brettell Lane 3 n.e., 9 m. 92 b. 2 o.
- 1 Oldswinford 1 s., 12 m. 92 b.
- 1 Bellbroughton 6 s., 13 m. 27 b. 2 o.
- 1 Wordsley 2 n., 9 m. 49 b. 1 o.

SUFFOLK. (IPSWICH.)

450, 19 days 146 miles; 10 days 126 miles.
Ex. 284,848 T. 174,688.

WOODBRIDGE 526 c. 56 l.

- 2 Woodbridge in 22 m. 14 b. 16 o.
- 1 Butley 8 e., 2 m. 17 b. 4 o.
- 1 Debenham 14 n.w., 3 m. 10 b. 2 o.
- 1 Ipswich 8 w.s.w., 7 m. 1 p. 13 b. 4 o.
- 1 Kirtton 9 s., 3 m. 12 b. 3 o.

HALESWORTH 602 c. 69 l.

- 2 Halesworth in 16 m. 24 b. 12 o.
- 1 Snape, &c. 16 s., 7 m. 16 b. 15 o.
- 1 Southwell 10 n., 7 m. 17 b. 7 o.
- 1 Framlingham 13 s.w., 9 m. 18 b. 6 o.
- 1 Sacton 9 s.w., 5 m. 16 b. 3 o.

STOWMARKET 479 c. 69 l.

- 3 Stowmarket in 32 m. 12 b. 6 o.
- 1 Eye 15 n.e., 7 m. 10 b. 3 o.
- 1 Botesdale, &c. 14 n., 9 m. 5 b.
- 1 Haughley 4 n.w., 10 m. 9 b. 2 o.
- 1 Needham 4 s.e., 7 m. 12 b. 3 o.

BURY ST. EDMUNDS 585 c. 103 l.

- 3 Bury in 23 m. 1 s. 91 b. 13 o.
- 1 Ixworth 7 n.e., 4 m. 22 b.
- 1 Dalham 10 w., 6 m. 18 b.
- 1 Hartest 10 w.s.w., 6 m. 17 b.
- 1 Battlesden 10 s.e., 9 m. 11 b.

SUDBURY 384 c. 95 l.

- 1 Sudbury in 7 m. 25 b. 9 o.
- 1 Haverhill 18 w.n.w., 7 m. 18 b. 7 o.
- 1 Clare 10 n.w., 7 m. 21 b. 2 o.
- 1 Glemsford 8 n., 5 m. 1 p. 1 s. 8 b. 1 o.
- 1 Cavendish 8 n.w., 6 m. 15 b.
- 1 Melford 4 n., 9 m. 9 b. 3 o.
- 1 Bures, &c. 6 s., 8 m. 12 b.
- 1 Ballingdon 1 w., 6 m. 12 b.

IPSWICH 529 c. 147 l.

- 7 Ipswich in 55 m. 1 p. 1 s. 39 b. 31 o.

SURREY. (BRENTFORD.)

400, 17 days 142 miles; 8 days 133 miles.
Ex. 954,448 T. 125,000.

CHERTSEY 1905 c. 268 l.

- 1 Egham 5 n.w., 3 m. 1 s. 6 b. 14 o.
- 1 Staines 4 n., 6 m. 10 b. 25 o.
- 1 Chertsey in 5 m. 7 b. 14 o.
- 1 Woking 7 s.w., 4 m. 1 p. 5 b. 6 o.
- 1 Hounslow 10 n.e., 2 m. 1 p. 9 b. 12 o.

KINGSTON 841 c. 160 l.

- 3 Kingston in 26 m. 13 b. 21 o.
- 1 Isleworth 6 n., 6 m. 10 b. 8 o.

- 1 Richmond 5 w., 3 m. 4 b. 29 o.
 1 Mortlake 8 n.e., 7 m. 1 b. 4 o.
- WANDSWORTH 1150 c. 168 l.**
 5 Wandsworth in 1 d. 9 m. 1 p. 8 b. 21 o.
 1 Waltham Green 4 n.w., 4 m. 9 b. 21 o.
 1 Fulham 8 n.w., 8 m. 3 b. 9 o.
- EWELL 1636 c. 220 l.**
 1 Lower green 7 ., 1 m. 1 p. 4 b. 14 o.
 1 Bromley 15 n.e., 4 m. 8 b. 14 o.
 1 Croydon 8 n.e., 4 m. 8 b. 18 o.
 1 Mitcham 7 n.e., 2 m. 1 p. 12 b. 41 o.
 1 Ewell in 7 m. 8 b. 14 o.
- DORKING 1900 c. 123 l.**
 1 Reigate 6 n.e., 5 m. 11 b. 7 o.
 1 Godstone 14 n.e., 3 m. 4 b. 15 o.
 1 Horsham 14 s., 6 m. 1 s. 17 b. 9 o.
 1 Dorking in 4 m. 30 b. 9 o.
 1 Leatherhead 5 n., 3 m. 15 b. 17 o.
- BRENTFORD 663 c. 103 l.**
 5 Brentford in 1 d. 14 m. 1 s. 5 b. 6 o.
 1 Strand-on-Green 1 ., 7 m. 7 b. 22 o.

SUSSEX. (Lewes.)

400, 15 days 161 miles; 10 days 159 miles.
 Ex. 300,470 T. 203,000.

- BATTLE 619 c. 531 l.**
 1 Battle in 1 m. 139 h. 5 b. 11 o.
 1 Gardener Street 12 w., 1 m. 156 h. 3 b. 4 o.
 1 Staplecross 7 n.e., 1 m. 130 h. 4 b. 6 o.
 1 Hastings 8 s., 6 b. 36 o.
 1 Rye 16 w., 85 h. 3 b. 12 o.
- TUNBRIDGE WELLS 1172 c. 665 l.**
 1 Mayfield 9 s., 249 h. 2 b. 5 o.
 2 Tunbridge Wells in 1 m. 1 p. 235 h. 7 b. 47 o.
 1 Matfield 8 w., 1 m. 177 h. 4 b. 9 o.
 1 East Grinstead 16 w., 1 m. 46 h. 13 b. 6 o.
- BRIGHTON 1130 c. 1066 l.**
 1 Shoreham 6 w., 7 m. 6 b. 7 o.
 1 Cuckfield 15 n., 2 m. 6 h. 11 b. 29 o.
 1 Hurstpierpoint 10 n., 4 m. 13 b. 28 o.
 2 Brighton in 11 m. 1 s. 13 b. 153 o.
 1 Regent Hill 2 w., 5 m. 9 b. 52 o.
- LEWES 949 c. 506 l.**
 1 Eastbourne 16 e., 5 m. 2 h. 4 b. 16 o.
 2 Lewes in 16 m. 1 s. 12 b. 17 o.
 1 Newhaven 8 s., 7 m. 5 b. 8 o.
 1 Uckfield 9 n., 3 m. 1 p. 173 h. 5 b. 17 o.

TAUNTON.

400, 23 days 221 miles; 12 days 192 miles.
 Ex. not returned T. not returned.

- TAUNTON 461 c. 112 l.**
 3 Taunton in 29 m. 1 s. 107 b. 32 o.
 1 Creech 4 e., 8 m. 25 b. 2 o.
 1 Lydeard 5 n., 6 m. 18 b. 6 o.
- BRIDGWATER 875 c. 233 l.**
 2 Bridgwater in 19 m. 1 s. 75 b. 11 o.
 1 Stowey 8 n.w., 7 m. 30 b. 4 o.
 1 Weston 17 n., 15 b. 28 o.

- 1 Axbridge 19 n.w., 2 m. 2 p. 5 b. 4 o.
 1 Burnham 9 n.w., 3 m. 25 b. 10 o.
- WELLS 573 c. 185 l.**
 2 Wells in 7 m. 4 p. 35 b. 11 o.
 1 Oak Hill 6 e., 12 m. 6 b.
 1 Holcombe 10 e., 5 m. 7 b. 2 o.
 1 Midsomer Norton 11 n.e., 11 m. 21 b.
 1 Shepton Mallet 5 s.e., 7 m. 12 b. 7 o.
- SHERBORNE 717 c. 181 l.**
 1 Sherborne in 9 m. 14 b. 8 o.
 1 Bruton 14 n., 6 m. 19 b. 4 o.
 1 Wincanton 11 n.e., 8 m. 20 b. 9 o.
 1 Stalbridge 8 e., 6 m. 19 b. 5 o.
 2 Yeovil 6 w., 8 m. 21 b. 13 o.
 1 Somerton 14 n.w., 3 m. 12 b. 4 o.
- CREWKERNE 946 c. 198 l.**
 1 Crewkerne in 6 m. 7 b. 6 o.
 1 Langport 13 n., 2 m. 18 b. 5 o.
 1 S. Petherton 5 n., 5 m. 14 b. 6 o.
 1 Beaminster 7 s.e., 7 m. 15 b. 3 o.
 1 Bridport 13 s.e., 4 m. 4 b. 9 o.
 1 Chard 9 w., 4 m. 9 b. 3 o.
 1 Ilminster 7 w., 4 m. 19 b. 9 o.

THIRSK.

25 days 304 miles; 12 days 275 miles.
 Ex. not returned T. not returned.

- THIRSK 1287 c. 36 l.**
 1 Thirsk in 4 m. 38 b. 8 o.
 1 Hovingham 18 s.e., 5 m. 15 b. 9 o.
 1 Easingwold 10 s.e., 8 m. 12 b. 8 o.
 1 Ripon 11 s.w., 11 m. 1 p. 36 b. 18 o.
 1 Northallerton 9 n.w., 7 m. 50 b. 10 o.
- KNARESBORO' 1173 c. 70 l.**
 1 Wetherby 7 s.e., 7 m. 1 p. 21 b. 9 o.
 1 Harewood 11 s., 9 m. 12 b. 3 o.
 1 Pateleybridge 9 n.e., 1 m. 17 b. 4 o.
 1 Knareboro' in 6 m. 45 b. 12 o.
 1 Low Harrogate 5 s.w., 5 m. 19 b. 42 o.
 1 Borobridge 7 n., 7 m. 18 b. 4 o.
- STOCKTON 1286 c. 122 l.**
 1 Hartlepool 13 n.e., 3 m. 21 b. 9 o.
 1 Stockton in 4 m. 17 b. 12 o.
 1 Norton 2 w., 3 m. 8 b.
 1 Guisboro' 7 s.e., 3 m. 23 b. 16 o.
 1 Stokesley 11 s.e., 3 m. 11 b. 9 o.
 1 Yarm 5 s., 3 m. 1 p. 14 b. 5 o.
- RICHMOND 1239 c. 43 l.**
 1 Bedale 12 s.e., 7 m. 15 b. 10 o.
 1 Masham 17 s.e., 6 m. 15 b. 4 o.
 1 Leyburn 10 s., 2 m. 23 b. 5 o.
 1 Askrigg 20 w.s.w., 3 m. 33 b. 3 o.
 2 Richmond in 10 m. 1 p. 53 b. 11 o.
 1 Fencote 10 e., 4 m. 16 b. 2 o.

WALES, EAST. (CARDIFF).

31 days 297 miles; 16½ days 231 miles.
 Ex. 86,000 T. 93,000.

- BRIDGEND 1301 c. 874 l.**
 1 Cowbridge 7 e., 9 m. 33 b. 2 o.
 1 Llantwit Major, 10 s.e., 9 m. 27 b.
 1 Bridgend in 5 m. 87 b. 4 o.

- 1 Pyle 7 w., 4 m. 54 b. 3 o.
 1 Neath 19 w., 9 m. 42 b. 4 o.
 1 Aberavon 18 w., 5 m. 73 b. 5 o.
- SWANSEA 1653 c. 1091 l.**
 1 Llangefellach 5 w., 5 m. 51 b. 2 o.
 1 Mumbles 5 s.w., 3 m. 38 b. 3 o.
 2 Reynoldstone, 12 s.w., 10 m. 18 b.
 1 Pontardawe 9 n.e., 4 m. 52 b. 3 o.
 2 Swansea in 11 m. 126 b. 31 o.
 1 Morriston 4 n.e., 4 m. 91 b. 5 o.
- MERTHYR 2087 c. 1607 l.**
 1 Carno 7 n.e., 1 m. 141 b.
 1 Aberdare 5 s.w., 138 b. 4 o.
 1 Cwm 8 n.e., 4 m. 124 b. 5 o.
 1 Merthyr in 1 m. 149 b. 19 o.
 1 Llantrisant 18 s., 6 m. 26 b. 3 o.
 1 Newbridge 13 s., 4 m. 126 b. 3 o.
- CARDIFF 2296 c. 1680 l.**
 2 Newport 12 s., 12 m. 113 b. 12 o.
 1 Risca 16 n.e., 5 m. 58 b.
 2 Cardiff in 14 m. 109 b. 18 o.
 1 Llystalybont 2 n., 5 m. 1 s. 50 b.
 1 Caerphilly 8 n., 6 m. 37 b. 1 o.
- ABERGAVENNY 2211 c. 1170 l.**
 1 Crickhowell 6 n.w., 6 m. 51 b. 1 o.
 1 Aberllynach 5 w., 4 m. 150 b. 4 o.
 2 Abergavenny in 16 m. 3 p. 88 b. 12 o.
 1 Glosmont 13 n.e., 4 m. 28 b. 1 o.
 1 Pontypool 10 s.s.w., 5 m. 137 b. 8 o.
 1 Pontaberbeeg 16 s.s.w., 6 m. 80 b.
- BRECON 811 c. 488 l.**
 2 Brecon in 15 m. 91 b. 10 o.
 1 Pontesenny 9 s.w., 7 m. 25 b. 1 o.
 1 Talgarth 9 n.e., 9 m. 27 b.
 2 Builth 17 n., 6 m. 44 b. 6 o.

WALES, MIDDLE. (WELSHPOOL.)

33 days 452 miles; 19 days 314 miles.
 Ex. 35,000 T. 61,000.

- CLUN 290 c. 291 l.**
 1 Clun in 8 m. 22 b. 2 o.
 2 Bishops Castle 6 n., 15 m. 37 b. 12 o.
 1 Knighton 7 s.w., 5 m. 33 b. 12 o.
 1 Rhayader 24 s.w., 1 m. 30 b. 9 o.

- KINGTON 343 c. 339 l.**
 1 Kington in 6 m. 32 b. 11 o.
 1 Presteign 7 n., 6 m. 20 b. 8 o.
 1 Eardisley 5 s., 6 m. 12 b. 5 o.
 2 Hay 14 s.w., 9 m. 37 b. 11 o.

- ABERYSTWICH 800 c. 402 l.**
 8 Aberystrwith in 22 m. 79 b. 32 o.
 1 Aberayron 17 s.w., 4 m. 34 b. 6 o.
 1 Tregaron 21 s.e., 26 b. 1 o.

- WELSHPOOL 474 c. 467 l.**
 2 Welshpool in 18 m. 46 b. 14 o.
 1 Llandiloies 28 s.w., 4 m. 33 b. 22 o.
 2 Newtown 14 s.w., 15 m. 52 b. 25 o.
 1 Montgomery 8 s.w., 8 m. 19 b. 8 o.
 1 Berriew 5 s.w., 6 m. 18 b. 7 o.

- LLANFYLLIN 281 c. 290 l.**
 1 Llanfyllin in 7 m. 26 b. 8 o.
 1 Marsh 18 s.w., 7 m. 20 b. 2 o.
 1 Llanfair 13 s.w., 6 m. 18 b. 10 o.

- 1 Llansaintffraid 7 s.w., 13 m. 17 b.
 1 Llansilin 9 n.e., 3 m. 30 b. 3 o.
- DOLGELLEY 380 c. 409 l.**
 1 Dolgelley in 2 m. 25 b. 21 o.
 1 Bala 19 n.e., 1 m. 28 b. 9 o.
 1 Barmouth 11 w., 2 m. 11 b. 9 o.
 1 Maentwrog 19 n.w., 1 m. 13 b. 13 o.
 1 Maehynlleth 18 s., 1 m. 25 b. 23 o.
 1 Towyn 21 s.w., 3 m. 16 b. 9 o.

WALES, NORTH. (CAERNARVON.)

30 days 362 miles; 18 days 307 miles
 Ex. 49,127 T. 65,722.

- LLANGEFINE 753 c. 334 l.**
 1 Bangor 19 s.w., 3 m. 81 b. 25 o.
 1 Beaumaris 12 s.e., 3 m. 10 b. 14 o.
 1 Garmeddwen 8 s.w., 4 m. 6 b. 1 o.
 1 Llangefine in 6 m. 19 b. 1 o.
 1 Llanerchymedd 15 n., 5 m. 11 b. 6 o.
 1 Holyhead 17 n.w., 3 m. 8 b. 6 o.

- PWLLHELI 458 c. 171 l.**
 2 Caernarvon 21 n., 8 m. 58 b. 18 o.
 1 Pontnewydd 19 n., 5 m. 21 b. 1 o.
 2 Pwllheli in 12 m. 50 b. 9 o.
 1 Crietheth 10 n., 3 m. 28 b. 5 o.

- CONWAY 570 c. 145 l.**
 1 Conway in 3 m. 36 b. 8 o.
 1 Aber 10 s.w., 3 m. 19 b. 3 o.
 1 Penybryn 5 s., 3 m. 16 b. 1 o.
 1 Llanrwst 12 s., 5 m. 33 b. 8 o.
 1 Abergelle 12 s.w., 4 m. 26 b. 5 o.
 1 St. Asaph 19 n., 5 m. 19 b. 17 o.

- RUTHIN 464 c. 64 l.**
 2 Denbigh 8 n.e., 18 m. 53 b. 14 o.
 2 Ruthin in 20 m. 65 b. 9 o.
 1 Corwen 18 s., 5 m. 34 b. 4 o.
 1 Llangollen 15 s.w., 8 m. 32 b. 6 o.

- HOLYWELL 756 c. 240 l.**
 2 Mold 10 s., 12 m. 35 b. 9 o.
 2 Holywell in 9 m. 1 p. 52 b. 11 o.
 1 Wheeler 8 w., 2 m. 2 p. 17 b.

WALES, WEST. (CARMARTHEN.)

27 days 250½ miles; 17 days 245 miles.
 Ex. 39,490 T. 46,572.

- LLANDILO 1139 c. 79 l.**
 2 Llandilo in 17 m. 51 b. 5 o.
 1 Cross Inn 8 s., 4 m. 1 s. 55 b. 2 o.
 1 Llangadock 7 n., 8 m. 38 b. 1 o.
 1 Llandovery 12 n., 6 m. 57 b. 8 o.
 1 Llansawel 12 n.n.e., 4 m. 26 b. 1 o.
 2 Llanelli 20 s.w., 13 m. 141 b. 13 o.

- NEWCASTLE EMLYN 664 c. 34 l.**
 1 Lampeter 30 s.w., 9 m. 50 b. 3 o.
 1 N. Emlyn in 7 m. 32 b. 9 o.
 1 Llandysall 9 10 m. 38 b. 1 o.
 1 New Quay 19 4 m. 22 b. 1 o.
 2 Cardigan 11 n.w.w., 13 m. 82 b. 7 o.
 1 Kilgeran 11 4 m. 90 b.

HAVERFORD WEST 901 c. 44 l.

- 1 Newport 24 n.n.e., 6 m. 33 b.
 1 Fishguard 16 n., 6 m. 42 b. 3 o.
 1 Solva 13 11 m. 23 b. 4 o.
 2 H. West in 16 m. 2 p. 101 b. 11 o.

- 1 Milford 8 s., 13 m. 35 b. 2 o.
 1 Johnstone 4 s., 11 m. 30 b. 1 o.
- PEMBROKE 884 c. 58 l.**
 1 Pembroke in 9 m. 35 b. 6 o.
 1 Pembroke Dock 2 w., 10 m. 53 b. 4 o.
 1 Milton 4 s., 19 m. 22 b.
 1 Lamphey 2 s., 20 m. 6 b.
 1 Tenby 10 s., 10 m. 47 b. 8 o.
 1 Narbeth 15 s.w., 13 m. 43 b. 3 o.
 1 Llandisillio 21 s.w., 14 m. 23 b. 1 o.
- CARMARTHEN 973 c. 65 l.**
 1 Langhorne 13 s.w., 3 m. 37 b. 5 o.
 1 Saint Clears 10 s.w., 8 m. 37 b. 1 o.
 1 Kidwelly 10 s.w., 5 m. 35 b.
 3 Carmarthen in 24 m. 141 b. 15 o.
 1 Llangendwrne 7 s.w., 4 m. 32 b.

WARE.

- 400, 17 days 171 miles; 12 days 133 miles.
 Ex. not returned T. not returned.
- BISHOP-STORTFORD 210 c. 367 b.**
 5 Bishop Stortford in 47 m. 11 b. 13 o.
 1 Stanstead 4 s.w., 9 m. 8 b. 3 o.
- WARE, 1st, 224 c. 349 l.**
 5 Ware in 60 m. 7 b. 8 o.
 1 Stanstead 4 s., 8 m. 3 b. 8 o.
- WARE, 2nd, 549 c. 780 l.**
 3 Ware in 30 m. 5 b. 4 o.
 1 Standon 6 s.w., 3 m. 1 p. 3 b. 5 o.
 1 Hatfield 10 w.s.w., 3 m. 7 b. 16 o.
 2 Hertford 2 w.s.w., 18 m. 18 b. 13 o.
- ROYSTON 853 c. 1519 l.**
 1 Royston in 13 m. 1 b. 6 o.
 1 Meldreth 4 s., 9 m. 2 b. 1 o.
 1 Lettlington 4 w., 9 m. 4 b. 1 o.
 1 Buntingford 8 s., 10 m. 8 b. 4 o.
 2 Biggleswade 12 w.s.w., 20 m. 18 b. 11 o.
- BALDOCK 786 c. 1458 l.**
 2 Baldock in 24 m. 4 b. 5 o.
 1 Ashwell 4 s.w., 2 m. 10 b.
 1 Shefford 8 w.s.w., 5 m. 8 b. 3 o.
 2 Hitchin 5 s.w., 16 m. 5 b. 9 o.
- ST. ALBANS 960 c. 1808 l.**
 2 St. Albans in 15 m. 13 b. 20 o.
 1 Luton 10 s.w., 10 m. 5 b. 26 o.
 1 Harpenden 5 s.w., 5 m. 1 p. 8 b. 7 o.
 2 Watford 8 s.s.w., 8 m. 2 p. 3 b. 11 o.

WORCESTER.

- 400, 23 days 171 miles; 16 days 137 miles.
 Ex. 140,000 T. 120,000.
- CAMPDEN 36 c. 922 l.**
 1 Stow 10 s., 8 m. 21 b. 7 o.
 1 Guiting 13 s.w., 7 m. 19 b. 8 o.

- 1 Moreton 8 s., 5 m. 29 b. 6 o.
 1 Shipston 8 s., 6 m. 22 b. 3 o.
 1 Alford Bridge 9 s., 7 m. 14 b. 2 o.
 1 Broadway 5 s.w., 11 m. 21 b. 2 o.
 1 Campden in 7 m. 25 b. 2 o.
- EVESHAM 19 c. 833 l.**
 1 Bidford 8 s.w., 11 m. 23 b. 3 o.
 2 Evesham in 15 m. 80 b. 9 o.
 2 Pershore 7 s.w., 15 m. 46 b. 7 o.
- BROMSGROVE 25 c. 896 l.**
 2 Bromsgrove in 15 m. 79 b. 10 o.
 1 Stoke 4 s.w., 2 m. 2 s. 10 b.
 1 Alnechurch 6 s.w., 10 m. 22 b. 2 o.
 1 Redditch 7 s., 12 m. 1 p. 66 b. 17 o.
- WORCESTER, 1st, 38 c. 1106 l.**
 6 Worcester in 1 d. 28 m. 163 b. 50 o.
 1 Malvern 8 w., 3 m. 34 b. 27 o.
- WORCESTER, 2nd, 26 c. 960 l.**
 1 Droitwich 7 s., 8 m. 43 b. 6 o.
 1 Ombersley 6 s.w., 11 m. 25 b. 5 o.
 2 Worcester in 15 m. 94 b. 11 o.
 1 Upton 10 s., 11 m. 29 b. 5 o.
- There are in this Collection 300 hop-planters surveyed during the season by 12 hop officers and 2 supervisors. There is also a permit writer in Worcester, 1st district.
- YORK.**
 17 days 274 miles; 12 days 221 miles.
 Ex. 122,901 T. 131,277.
- SNAITH 1871 c. 868 l.**
 1 Snaith in 6 m. 10 b. 1 o.
 1 Howden 10 s.w., 4 m. 13 b. 7 o.
 1 Goole 9 s., 3 m. 7 b. 4 o.
 1 Thorne 8 s., 7 m. 18 b. 7 o.
 1 Norton 8 s.w., 6 m. 16 b. 8 o.
 1 Selby 8 s., 5 m. 17 b. 4 o.
- YORK 1809 c. 1070 l.**
 3 York in 15 m. 1 s., 82 b. 39 o.
 1 Pocklington 14 s., 6 m. 15 b. 7 o.
 1 Tadcaster 10 s.w., 7 m. 17 b. 5 o.
 1 Tockwith 10 w., 6 m. 17 b.
- PONTEFRAC 800 c. 486 l.**
 2 Pontefract in 26 m. 35 b. 4 o.
 1 Kippax 7 s.w., 12 m. 16 b. 1 o.
 1 Knottingley 4 s., 10 m. 20 b. 4 o.
 1 Ackworth 4 s., 6 m. 23 b. 1 o.
 1 Aberford 11 s., 7 m. 31 b. 7 o.
- DONCASTER 958 c. 550 l.**
 8 Doncaster in 24 m. 107 b. 14 o.
 1 Tickhill 8 s., 10 m. 1 p. 22 b. 3 o.
 1 Wickersley 13 s.w., 7 m. 14 b.
 1 Bawtry 9 s.w., 7 m. 22 b. 8 o.
 1 Brodsworth 6 s.w., 9 m. 16 b.
 1 Conisbrough 6 s.w., 10 m. 17 b. 2 o.

SCOTLAND.

ABERDEEN.

400, 18 days 192 miles. Ex. 100,877.

- ABERDEEN, 1st, 499 c. 54 l.
 3 Aberdeen in 6 m. 1 s. 5 b. 18 o.
 2 Glenburn 2 w., 1 d. 2 m.
 2 Devanha 2 s., 1 d. 2 m. 1 b.
 1 Old Aberdeen 2 w., 5 m. 3 b. 1 o.
 ABERDEEN, 2nd, 261 c. 83 l.
 3 Aberdeen in 2 d. 8 m. 4 b. 19 o.
 1 Peter Culter 8 w., 1 p. 3 o.
 2 Stonehaven 16 s., 1 d. 5 m. 1 b. 5 o.
 ABERDEEN, 3rd, 76 c. 5 l.
 3 Auchmull in 4 m. 8 p. 2 b. 7 o.
 2 Monymusk 16 n.w., 1 d. 5 m. 11 o.

ABOYNE 107 c. 6 l.

- 1 Aboyne in 2 m. 1 b. 10 o.
 1 Kincardine 5 w., 4 m. 2 b. 4 o.
 1 Marywell 5 s., 1 m. 6 o.
 1 Alford 19 w., 2 m. 4 o.
 1 Balmacraich 16 s., 5 o.
 1 Lochnagar 18 s., 1 d. 1 m.
 1 Crathie 20 s., 1 d. 1 m.
 1 Houghhead 19 s.w., 4 o.

OLD MELDRUM 149 c. 9 l.

- 3 Old Meldrum in 1 d. 3 m. 1 b. 5 o.
 1 Jericho 14 w., 1 d. 1 m.
 1 Portelphenston 7 s., 2 m. 1 b. 5 o.
 1 Pitmachie 13 n.w., 4 m. 2 o.
 1 Fyvie 8 s., 3 m. 9 o.
 1 Ellon 13 s., 3 m. 2 b. 7 o.

LONGSIDE 233 c. 42 l.

- 1 Longside in 4 m. 1 b. 19 o.
 1 Old Deer, 6 w., 2 m. 1 b. 30 o.
 1 Strichen 10 n.w., 2 m. 1 b. 22 o.
 1 Glenbughty 17 n., 1 d. 1 m. 1 b.
 1 Peterhead 7 s., 2 m. 3 b. 12 o.
 1 Fraserburgh 15 n., 4 m. 13 o.
 1 Errolston 18 s., 2 m. 20 o.

ARGYLE, NORTH.

The districts formerly comprised in this Collection are now collected by their respective supervisors, as follows:—

FORT WILLIAM 81 c. 231 l. Ex. 2020.

- 1 Bennevis 2 n.e., 1 d. 1 m.
 2 Fort William in 17 o.
 2 Preventive men.

LONG ISLAND 217 l. Ex. 233.

- 1 Lochmaddy 85 s., 1 o.
 3 Preventive men.

MULL 175 c. 185 l. 1 d. 4 m. 2 o. Ex. 220.

- 1 Bunessan 40 s., 1 o.
 3 Preventive men.

OBAN 122 l. Ex. 5271.

- 2 Oban in 1 d. 1 m. 7 o.
 1 Tullich 18 s.w., 1 d. 2 m.
 1 Taynult 12 n.e., 4 o.

POOLEWE 2 o. 4 c. 87 l. Ex. 188.

- 1 Poolewe in 2 o.

SKYE 120 c. 129 l. Ex. 3400

- 2 Carbost 20 w., 1 d. 1 m.
 1 Broadford 26 s., 5 o.
 3 Preventive men.

ARGYLE, SOUTH. (CAMPBELTON.)

2nd clk. 120, 19 days 235 miles. Ex. 300,000.

CAMPBELTON, 1st, 80 c.

- 8 Campbelton in 5 d. 16 m. 2 o.

CAMPBELTON, 2nd, 87 c.

- 10 Campbelton in 5 d. 15 m.

CAMPBELTON, 3rd, 44 c.

- 10 Campbelton in 5 d. 12 m.

CAMPBELTON, 4th, 157 c. 2 l.

- 11 Campbelton in 5 d. 13 m. 2 o.

CAMPBELTON, 5th, 44 c. 1 l.

- 9 Campbelton in 4 d. 11 m. 2 o.

PORT ELLEN 46 c.

- 4 Port Ellen in 1 d. 3 m. 3 o.
 2 Kildalton 2 n.e., 1 d. 1 m.
 2 Lugavulin 3 n.e., 1 d. 3 m.
 2 Laphroig 4 n.e., 1 d. 2 m.
 3 Ardbeg 5 n.e., 1 d. 2 m.

BRIDGEND 164 c. 1 l.

- 1 Bridgend in 1 o.
 1 Lossit 6 n.e., 1 d. 1 m.
 2 Bowmore 8 s., 1 d. 2 m. 5 o.
 1 Tallant 6 s., 1 d. 1 m.
 1 Port Charlotte 8 s.w., 1 d. 2 m. 1 o.
 1 Octomore 8 s.w., 1 d. 1 m.
 2 Jura 20 n.e., 1 d. 1 m. 1 o.
 2 Caol Ila 12 n.e., 1 d. 1 m. 1 o.

LOCHGILPHEAD 429 c. 3 l.

- 3 Lochgilphead in 1 d. 2 m. 8 o.
 2 Glengelp 2 s., 1 d. 1 m.
 1 Tarbert 14 s., 1 o.
 1 Otter Ferry 9 s.e., 5 o.

In this Collection are 71 duty-free warehouses.

AYR. (GREENOCK.)

400, 2nd clk. 120. 13 days 260 miles. Ex. 164,852.

PAISLEY 1982 c. 1017 l.

- 5 Paisley in 2 d. 12 m. 3 s. 3 b. 9 o.
 1 Johnstone 4 s.w., 1 s.
 1 Beith 11 s.w., 5 o.

KILMARNOCK 2226 c. 1127 l.

- 2 Kilmarnock in 3 m. 1 p. 2 b. 12 o.
 1 Lamash 36 w., 3 o.
 1 Brodick 31 w., 4 o.
 1 Irvine 7 w.n.w., 1 m. 1 b. 7 o.
 1 Ardrossan 16 n.w.n., 10 o.

AYR 1915 c. 1009 l.

- 1 Ayr in 3 m. 1 s. 2 b. 12 o.

- 1 Newton in 1 m. 2 b. 3 o.
- 1 Girvan 22 s.w., 4 o.
- 1 Maybole 9 s., 7 o.
- 1 Mauchline 12 s.w., 3 m. 1 b. 10 o.

DUMBABTON 756 c. 396 l.

- 1 Dumbarton in 1 d. 2 m. 1 b. 2 o.
- 1 Dalmuir 8 s.w., 1 d. 1 m. 1 p. 1 b. 1 o.
- 1 Gartocharn 9 s., 2 m. 4 o.
- 1 Luss 16 w., 6 o.
- 1 Helnsburgh 8 s.w., 1 m. 8 o.
- 1 Littlemill 4 s.w., 1 d. 4 m. 1 o.

GREENOCK 1804 c. 876 l.

- 4 Greenock in 1 d. 9 m. 4 p. 1 s. 2 b. 8 o.
- 1 Port Glasgow 3 s., 1 o.
- 1 Rothay 22 s.w., 7 o.
- 1 Dunoon 10 w., 7 o.

CAITHNESS.

The districts formerly comprised in this Collection are now collected by their respective supervisor, as follows:—

ORKNEY 456 c. 37 l. Ex. 4650.

- 2 Stromness 16 w., 1 d. 1 m. 9 b. 1 o.
- 1 Evie 19 s.w., 4 b.
- 3 Kirkwall in 2 d. 3 m. 5 b. 3 o.
- 1 St. Margaret's Hope 16 s., 1 b.
- 1 Wassiter 30 s.w., 2 b.

SHETLAND 418 c. 181 l. Ex. 350.

- 1 Lerwick in.

THURSO 4 c. 294 l. Ex. not returned.

- 1 Thurso in 3 b. 4 o.
- 1 Geise 4 s., 1 d. 1 m. 1 o.
- 1 Wolfburn 2 s.w., 1 d. 2 m. 1 o.
- 1 Todholes 4 s.w., 1 d. 2 m. 1 o.
- 1 Gerston 9 s., 1 d. 1 m. 1 o.
- 1 Tongue 48 w., 2 o.

WICK 234 c. 396 l. Ex. 12,000.

- 3 Wick in 1 d. 2 m. 2 b. 3 o.
- 1 Helmsdale 40 s.w., 2 m. 3 o.

DUMFRIES.

11 days 261 miles. Ex. 46,760.

DUMFRIES 2658 c. 19 l.

- 1 Castle Douglas 18 w., 1 m. 1 p. 1 b. 7 o.
- 1 New Galloway 23 s.w., 2 o.
- 1 Thornhill 15 s., 1 m. 1 b. 9 o.
- 1 Dumfries in 5 m. 3 b. 11 o.
- 1 Maxwelltown 1 w., 1 m. 1 b. 8 o.

WIGTON 1887 c. 12 l.

- 1 Gatehouse 18 s., 1 m. 1 b. 10 o.
- 2 Bladnoch 2 s., 1 d. 2 m.
- 1 Wigton in 2 m. 2 b. 11 o.
- 1 Stranraer 23 s., 1 m. 1 b. 10 o.

LANGHOLM 682 c. 4 l.

- 2 Annan 18 w., 1 d. 4 m. 1 b. 4 o.
- 3 Langholm in 1 d. 2 m. 1 b. 4 o.
- 1 Gientarris 4 s.w., 1 d. 1 m.

EDINBURGH.

600, 1st clk. 160, 2nd 130, 3rd 100. Ex. 508,348.

EDINBURGH, 1st, 1067 c. 1096 l.

- 9 Edinburgh in 1 d. 68 m. 13 b. 13 o.

EDINBURGH, 2nd, 600 c. 771 l.

- 2 Juniper Green in 3 p.
- 1 Edinburgh 6 s., 6 m. 1 b. 9 o.
- 1 Stateford 2 s.w., 1 p. 12 o.
- 1 Currie 3 w., 1 p. 2 o.
- 1 Balerno 5 w., 1 p.
- 1 Collinton 2 s., 1 p. 16 o.

EDINBURGH, 3rd, 738 c. 984 l.

- 9 Edinburgh in 2 d. 17 m. 5 b. 15 o.

LEITH, 1st, 487 c. 495 l.

- 9 Leith in 1 d. 5 m. 1 s. 2 b. 3 o.

LEITH, 2nd, 830 c. 992 l.

- 7 Leith in 1 d. 7 m. 2 s. 3 o.
- 2 Edinburgh 2 w., 5 m. 34 o.

ELGIN.

10½ days 161 miles. Ex. 101,764.

BANFF 479 c. 8 l.

- 2 Banff in 1 d. 2 m. 2 b. 2 o.
- 2 Tochineal 14 w., 1 d. 3 m.
- 1 Cullen 14 w., 4 m. 2 b. 2 o.
- 1 Macduff 2 s., 2 m. 2 o.
- 1 Glenbarry 11 s.w., 1 d. 1 m.
- 1 Foggytone 9 s., 1 m. 1 o.
- 1 Turfrit 12 s.w., 4 m. 2 b. 3 o.

HUNTLEY 290 c. 7 l.

- 2 Huntley in 5 m. 2 b. 2 o.
- 2 Perries Mill 1 s., 1 d. 3 m.
- 2 Glendronach 10 s.w., 1 d. 2 m.
- 1 Rhynie 10 s., 2 m.
- 2 Keith 11 s.w., 1 d. 2 m. 4 o.
- 1 Fife Keith 11 s.w., 2 m. 1 b.

GRANTOWN 140 c. 1 l.

- 1 Balmenach 4 s., 1 d. 1 m.
- 1 Ballintomb 4 w., 1 d. 1 m. 2 o.
- 1 Kingsale 28 w., 1 m. 1 b. 4 o.
- 1 Delnabo 16 s., 1 d. 1 m.
- 2 Drumlin 21 s.w., 1 d. 1 m.
- 1 Achorachan 21 s.w., 1 d. 1 m.

ROTHES 98 c. 4 l.

- 1 Rechlierech 11 s.w., 1 d. 1 m. 1 o.
- 1 Duftown 8 s.w., 1 d. 1 m. 2 o.
- 1 Lyne of Rutherie 9 s.w., 1 d. 1 m. 2 o.
- 2 Rothies in 1 d. 2 m. 4 o.
- 1 Macallan 4 s.w., 1 d. 1 m. 1 o.
- 1 Cardow 10 s.w., 1 d. 1 m.

ELGIN 290 c. 3 l.

- 2 Forres 12 w., 1 d. 3 m. 1 b. 3 o.
- 1 Kilnlist 9 w., 1 d. 1 m.
- 2 Elgin in 6 m. 5 b. 10 o.
- 1 Milntoduff 4 w., 1 d. 1 m.
- 1 Linkwood 2 s.w., 1 d. 2 m.

In this collection are 131 Bye-Maltsters.

GLASGOW.

500, 1st clk. 170; 2nd 130; 3rd 100.

GLASGOW, 1st, 1756 c. 1737 l. Ex. not returned.

- 10 Glasgow in 3 d. 8 m. 4 s. 2 b. 13 o.

GLASGOW, 2nd, 3120 c. 3065 l.

- 10 Glasgow in 2 d. 10 m. 2 p. 2 s. 25 o.

GLASGOW, 3rd, 2886 c. 2846 l.
12 Glasgow in 3 d. 9 m. 3 s. 2 b. 12 o.

GLASGOW, 4th, 1328 c. 1294 l.
10 Glasgow in 2 s., 48 o.

GLASGOW, 5th, 540 c. 536 l.
12 Glasgow in 3 d. 6 m. 6 s. 6 o.

GLASGOW, 6th, 1069 c. 1062 l.
9 Glasgow in 2 d. 10 m. 3 p. 2 s. 1 b. 16 o.

HADDINGTON.

15 days 237 miles. Ex. 127,638.

HADDINGTON 787 c. 321 l.
3 Haddington in 1 d. 4 m. 3 b. 6 o.
1 North Berwick 10 n.e., 5 m. 2 b. 5 o.
2 Kinchie 8 s.w., 1 d. 1 m.
2 Preston Pans 10 w.s.w., 7 m. 1 s. 1 b.

LASSWADE 1115 c. 444 l.
1 Lasswade in 2 p. 1 o.
1 Springfield 2½ s.w., 1 p.
1 Dalkeith 2 n.e., 2 m. 1 p. 1 b. 6 o.
1 Bonnyrigg 2 s., 1 p. 1 o.
1 Portobello 8 n., 2 m. 1 p. 1 b. 4 o.

PENNICUICK 417 c. 158 l.
3 Pennicuick in 4 m. 3 o.
1 Auchindinny 3 s., 1 p.
1 Peebles 13 s.e., 1 m. 2 b. 7 o.

MELROSE 1937 c. 737 l.
1 Melrose in 2 m. 1 b. 7 o.
1 Galashiels 5 w.n.w., 2 m. 1 b. 10 o.
1 Hawick 20 s., 1 m. 1 b. 3 o.
1 Jedburgh 14 s.e., 2 m. 2 b. 5 o.
1 Kelso 14 e., 2 m. 1 b. 6 o.

CHIRNSIDE 1016 c. 402 l.
1 Chirnside in 1 m. 1 p. 1 b.
1 Coldstream 15 s., 1 m. 3 b. 6 o.
1 Dunse 7 s.w., 1 m. 3 b. 3 o.
1 Ayton 5 n.e., 1 m. 2 p. 1 b. 1 o.
1 Dunbar 23 n.w., 4 m. 3 b. 2 o.

INVERNESS.

9 days 177 miles. Ex. 71,979.

CONONBRIDGE 146 c. 68 l.
2 Ord 4 w., 1 d. 1 m.
1 Beaully 7 w., 2 m. 2 b. 3 o.
1 Dingwall 3 n.e., 7 m. 7 b. 6 o.
1 Cononbridge.
2 Preventive men in.

ALNESS 184 c. 207 l.
3 Alness in 2 d. 3 m. 1 o.
1 Invergordon 4 s., 4 m. 2 b. 3 o.
1 Fortrose 15 s., 1 d. 2 m. 1 b. 1 o.
1 Fortmarty 14 s., 1 m. 1 b. 1 o.
2 Preventive men.
2 Assistants in.

TAIN 156 c. 181 l.
1 Balblair 6 w., 1 d. 2 m.
2 Clynesh 28 n.e., 1 d. 2 m. 3 o.
1 Glenmorangie 2 w., 1 d. 1 m.
1 Tain in 1 m. 1 b. 7 o.
1 Bonar 15 w., 1 m. 1 b. 7 o.
1 Bonar bridge, Preventive station 15 w.
2 Preventive men.

DRUMNADROCHIT 63 c. 71 l.

1 Dr. in 1 m. 2 b. 2 o.
1 Invermoriston 13 w., 1 d. 1 m.
1 Ft. Augustus 21 w., Prev. st. 4 o.
3 Preventive men.

INVERNESS 168 c. 191 l.

2 Brackla 16 n.e., 1 d. 2 m.
1 Nairn 16 n.e., 2 d. 2 b. 4 o.
4 Inverness in 1 d. 5 m. 4 b. 10 o.
2 Preventive men.

LINLITHGOW.

12 days 234 miles. Ex. 206,109.

FALKIRK 715 c. 784 l.
2 Bankair 8 w., 1 d. 2 m.
2 Broomhill 5 w., 1 d. 2 m.
3 Falkirk in 1 d. 5 m. 3 b. 6 o.
1 Denny 5 w., 2 p. 2 o.
1 Camelon 1 w., 1 d. 1 m.
1 Kirkintilloch 17 w., 1 d. 3 o.

QUEENSFERRY 202 c. 219 l.
2 Kirkliston 4 s., 1 d. 3 m.
3 Queensferry in 1 d. 3 m. 2 p. 3 o.
2 Bo'ness 7 w., 1 d. 4 m. 1 o.

LINLITHGOW 264 c. 237 l.
1 Blackburn 11 s., 3 p. 2 o.
3 Bathgate 7 s., 1 d. 4 m. 1 b. 4 o.
4 L. in 1 d. 8 m. 2 p. 1 s. 1 b. 3 o.

HAMILTON 1555 c. 1152 l.
3 Airdrie 8 n., 1 d. 2 m. 1 p. 2 b. 6 o.
1 Moffat Mill 11 n., 1 p.
3 Wishaw 5 s., 1 d. 7 m. 1 o.
1 Hamilton in 1 m. 1 b. 7 o.
1 Strathaven 8 s., 1 m. 3 b. 5 o.
1 Lanark 15 s., 1 m. 1 b. 4 o.
1 Biggar 27 s.e., 5 o.

MONTROSE. (DUNDEE.)

10 days 186 miles. Ex. 136,116.

ST. ANDREWS 1228 c. 1206 l.
1 St. Andrews in 6 m. 4 b. 10 o.
1 Anstruther 10 s., 4 m. 4 b. 7 o.
2 Seggie 5 n., 1 d. 2 m.
1 Cupar 10 s., 7 m. 7 b. 3 o.

BLAIRGOWRIE 826 c. 796 l.
1 Blairgowrie in 3 m. 1 b. 5 o.
1 Cally 7 n., 1 o.
1 Meikle 10 s., 2 m., 5 b. 8 o.
1 Kerriemuir 15 s., 3 m. 3 b. 3 o.

DUNDEE 3014 c. 2984 l.
3 Dundee in 15 m. 23 b. 12 o.
1 Dron 7 w., 1 d. 1 m.
1 Invergowrie 4 w., 2 m. 1 p. 2 b. 1 o.
1 Broughty ferry 4 s., 3 m. 3 b. 2 o.
1 Arbroath 17 s., 5 m. 7 b. 2 o.

BRECHIN 1857 c. 1800 l.
1 Montrose 8 s., 3 m. 3 b. 5 o.
1 Lawrence Kirk 13 s., 2 m. 2 b. 7 o.
1 Fettercairn 13 s., 1 d. 2 m.
3 Brechin in 2 d. 4 m. 2 b. 3 o.
1 Forfar 14 s., 5 m. 8 b. 2 o.

PERTH.

400, 9 days 167 miles. Ex. 70,002.

PERTH 1440 c. 687 l.

- 2 Perth in 7 m. 6 b. 15 o.
- 1 Brigend 1 n., 3 m. 2 b.
- 1 Dunkeld 16 n.w., 4 m. 4 o.
- 1 Clockerie 1 s., 1 d. 1 m.

PITLOCHRY 70 c. 63 l.

- 4 Pitlochry in 3 d. 16 m. 1 o.
- 1 Moulin 1 n., 1 d. 2 m.
- 1 Killivoulin 4 n.e., 1 d. 1 m.
- 1 Blair 8 n.w., 3 o.

LOGIERAIT 56 c. 55 l.

- 1 Logierait in 7 m. 1 o.
- 1 Dalguise 4 n., 1 d. 1 m.
- 1 Ballechin 2 n.w., 1 d. 3 m.
- 1 Tomdachoil 4 s., 1 d. 3 m.
- 1 Haugh 4 n., 1 d. 3 m. 1 o.
- 1 Tullymet 3 s.w., 1 d. 3 m.

ABERFELDY 151 c. 93 l.

- 2 Aberfeldy in 4 m. 4 o.
- 1 Grandtully 4 n., 1 d. 2 m.
- 1 Pittie 2 s.e., 1 d. 3 m.
- 1 Blackhill 5 n., 1 d. 1 m.
- 1 Tummelbridge 14 n.w., 5 o.

CRIEFF 598 c. 310 l.

- 1 Crieff in 2 b. 9 o.
- 1 Hosh 3 n.w., 1 d. 1 m.
- 1 Killin 27 n.w., 4 o.
- 1 Amulrie 13 n., 1 o.
- 1 Auchterarder 10 s.e., 3 m. 3 b. 4 o.

AUCHTERMUCHTY 655 c. 355 l.

- 2 Auchtermuchty in 1 d. 12 m. 2 b. 5 o.
- 1 Milnathort 10 n., 4 m. 2 b. 5 o.

- 1 Newburgh 6 n., 3 m. 4 b.
- 1 Newton of Falkland 5 s., 1 d. 3 m. 2 b.
- 1 Edenbank 5 s.e., 1 d. 1 m.

STIRLING. (ALLOA.)450, 8 days 121 miles; 9 days 131 miles.
Ex. 369,000.**BURNTISLAND 899 c. 900 l.**

- 2 Dunfermline 12 w., 5 m. 1 s. 5 b. 6 o.
- 2 Burntisland in 1 d. 5 m. 2 o.
- 2 Kirkaldy 6 n., 7 m. 5 b. 6 o.
- 2 Auchtertool 6 n.e., 1 d. 2 m.

WINDYGATES 321 c. 340 l.

- 1 Kennoway 1 n., 8 m. 4 b. 4 o.
- 1 Windygates in 1 d. 3 m.
- 2 Markinch 4 w., 3 p. 1 o.
- 1 Leslie 7 w., 2 m. 1 p. 2 b. 2 o.

ALLOA 838 c. 341 l.

- 3 Kilbegie 5 n., 1 d. 2 m.
- 1 Kincardine 6 n., 2 m. 8 o.
- 1 Alloa in 1 d. 26 m. 7 b. 5 o.
- 1 Dollar 7 n., 2 m. 1 p. 4 o.

TULLIBODY 409 c. 427 l.

- 3 Menstry 1 n., 1 d. 4 m. 1 o.
- 3 Cambus 1 s., 1 d. 8 m. 1 b.
- 2 Stirling 6 w., 12 m. 1 p. 7 b. 8 o.
- 1 Bridge of Allan 6 n.w., 8 o.

KIPPEN 234 c. 238 l.

- 2 Chartershall 12 s.e., 1 d.
- 1 Kippin in 3 m. 1 o.
- 1 Bucklyvie 6 w., 3 m. 4 o.
- 1 Burnfoot 16 s.w., 1 d. 1 m. 1 o.
- 1 Gargunnoch 6 s.e., 1 d. 1 m.
- 1 Callander 16 n., 7 o.

IRELAND.**ATHLONE.**14 days 269 miles; 15 days 306 miles.
Ex. 18,717 Q. R. 5,589.**ATHLONE 624 c. 324 l.**

- 3 Athlone in 1 d. 3 m. 1 b.
- 1 Ballymahon 13 n.e.
- 1 Roscommon 20 n.w.
- 1 Ferbane 13 s.e.

BALLINASLOE 473 c. 278 l.

- 1 Ballinasloe in 1 d. 1 m.
- 1 Ballygar 20 n.
- 1 Longhrea 20 w.

KILBEGGAN 599 c. 373 l.

- 3 Kilbeggan in 1 d. 1 m.
- 1 Mullingar 16 n.e., 1 m. 1 b.
- 1 Milltown 12 n., 1 m.
- 1 Castlepollard 29 s.w.

LONGFORD 512 c. 404 l.

- 3 Longford in 1 m.
- 1 Granard 16 n.e.
- 1 Stokestown 16 n.w.
- 1 Castleroa 36 n.w.

BANDON.14 days 273 miles; 15 days 312 miles.
Ex. 31,000 Q. R. 4800.**SKIBBEREEN 432 c. 446 l.**

- 1 Skibbereen in 1 m. 1 b.
- 1 Clonakilty 24 n.e., 1 m. 1 b.
- 1 Bantry 20 n.w.

BANDON 575 c. 614 l.

- 3 Bandon in 2 d. 6 m. 2 b. 2 o.
- 1 Enniskean 10 w., 1 p.
- 1 Macroom 20 n.w.
- 1 Kinsale 13 s.e., 1 m. 1 b.

TRALEE 619 c. 548 l.

- 1 Tralee in 2 m. 1 b.
- 1 Killarney 23 s.e.
- 1 Milltown 18 s.
- 1 Listowell 17 n.e.

BELFAST.

450, 2nd clk. 130; 6 days 124 miles; 6 days 120 miles. Ex. 220,000 Q. R. 553.

HILLSBORO' 681 c. 674 l.

- 4 Hillsboro' in 1 d. 2 m. 1 b.

1 Lisburn 4 n.w., 1 m. 1 b.
 1 Glenavy 12 n.w.
 1 Dromore 5 s.w.
CARRICKFERGUS 439 c. 473 l.
 2 Carrickfergus in 1 d. 1 m.
 1 Larne 12 s.
 2 Ballyclare 11 w., 2 p.
BELFAST, 1st, 1546 c. 1828 l.
 11 Belfast in 1 d. 4 m. 5 b.
COMBER 716 c. 788 l.
 4 Comber in 2 d. 2 m.
 1 Newtonards 4 s., 1 b.
 1 Kirkcubbin 16 s.
BELFAST 2nd
 4 Belfast in, warehousekeepers; 36
 warehouses.

BIRR.

8 days 162 miles. Ex. 31,964 Q. R. 4889.
TULLAMORE 387 c. and l.
 3 Tullamore in 1 d. 8 m. 2 b.
 1 Frankford 14 s., 1 d. 2 m. 1 b.
RATHDOWNEY 1287 c. and l.
 1 Maryboro' 24 n.w.
 1 Abbeyleix 13 n.w., 1 m.
 1 Rathdowney in 1 m. 1 b.
 1 Templemore 18 s.
 1 Roscrea 16 s.w., 1 d. 1 m. 1 b.
BIRR 389 c. and l.
 8 Birr in 1 d. 2 m.
 1 Banagher 9 w., 1 d. 1 m. 1 b.
CLOUGHJORDAN 440 c. and l.
 2 Cloughjordan in 1 d. 1 m.
 2 Ballinderry 13 w., 1 d.
 1 Nenagh 1 s.w.

COLERAINE.

11½ days 216 miles; 12 days 242 miles.
 Ex. 32,000 Q. R. 300.
NEWTOWNLIMAVADY 500 c. 324 l.
 1 Newtownlimavady in 1 m. 1 b.
 1 Roemill in 1 d. 1 m.
 1 Dungiven 9 s.
 1 Clandy 16 s.w.
BANN 788 c. 426 l.
 1 Ballymoney in 1 m. 1 b.
 2 Bann 5 w., 1 d. 1 m.
 1 Killyrea 12 s.
 1 Iderone 10 n.w.
MAGHERAFELT 900 c. 459 l.
 1 Magherafelt in
 1 Luney 3 w., 1 d. 1 b.
 1 Maghera 11 n., 1 m.
 1 Cookstown 11 s.w.
ANTRIM 1244 c. 615 l.
 1 Antrim in 1 p. 1 b.
 1 Dunadry 4 s., 1 p.
 1 Ballymena 11 w., 1 b.
 1 Glenavil 25 n.w.
COLERAINE 503 c. 246 l.
 3 Coleraine in 1 d.
 2 Bushmills 9 n.w., 2 d. 2 m.

CORK.

450, 2nd clk. 120, 6 days 105 miles; 5½ days
 85 miles. Ex. 219,746 T. 46. Q. R. 2428.
MIDDLETON 540 c. 719 l.
 3 Middleton in 1 d. 1 m.
 1 Ballinacurra 2 s.w., 2 m.
 1 Lismore 18 n., 1 m. 1 b.
RIVERSTOWN 694 c. 741 l.
 2 Riverstown in 1 d. 1 m. 1 p.
 1 Watergrasahill 8 n., 2 p.
 1 Fermoy 17 w., 1 m. 1 b.
 1 Cork 6 w., 3 m. 1 b.
CORK, 1st, 494 c. 648 l.
 8 Cork in 2 d. 8 m. 2 b.
 1 Cork in Permit-writer.
CORK, 2nd, 371 c. 346 l.
 7 Cork in 8 d. 3 m.
 1 Inniscarra 9 w., 2 p.

DROGHEDA.

12 days 210 miles. Ex. 193,684. Q. R. 6000.
NAYAN 1447 c. and l.
 1 Nayan in 1 s.
 1 Trim 9 s.w., 1 p.
 1 Athboy 14 w.
 1 Kells 10 n.w.
 1 Virginia 23 n.w.
 1 Bailieboro' 25 n.w.
BELTURBET 978 c. and l.
 1 Cavan 10 s.w.
 8 Beltrubet in 1 d. 1 m.
 1 Clones 14 n.w., 1 s.
 1 Newtownbutler 10 w.
CARRICKMACROSS 735 c. and l.
 1 Cooteshill 18 w.n.w.
 4 Carrickmacross in 2 d. 2 m.
 1 Ardee 12 s., 4 m.
DROGHEDA 886 c. and l.
 5 Drogheda in 1 d. 5 m. 2 s. 1 b.
 1 Balbriggan 16 s.e., 2 m.
DUNDALK 767 c. and l.
 5 Dundalk in 1 d. 2 m. 4 s. 1 b.
 1 Castlebellingham 16 s., 2 m. 1 b.

DUBLIN.

600 1st clk. 180, 2nd clk. 150, 3rd 110; 2½
 days 60 miles. Ex. 330,000 Q. R. 1200
DUBLIN, 1st, 329 c. 743 l.
 8 Dublin in 2 d. 2 m. 1 p. 4 b.
DUBLIN, 2nd, 214 c. 453 l.
 6 Dublin in 2 d. 9 m. 3 b.
DUBLIN, 3rd, 941 c. 2045 l.
 10 Dublin in 1 d. 6 m. 1 p. 2 b.
DUBLIN, 4th, 1327 c. 2812 l.
 3 Dublin in 3 m. 2 b.
 1 Wicklow 30 s.e.
 1 Bray 13 s.e., 1 m. 1 p. 1 b.
HAROLDSCROSS 309 c. 590 l.
 1 Rathfarnham 4 s., 4 p.
 1 Tallaght 7 s.w., 1 m. 3 p.

- 1 Goldenbridge 4 s., 1 p.
- 1 Drymnagh 5 s., 2 p.
- 1 Haroldscross in 1 p.

GALWAY.

21 days 836 miles; 13 days 177 miles.
Ex. 42,772.

GALWAY 329 c. 283 l.

- 3 Galway in 2 d. 5 m. 1 p. 4 b. 15 o.
- 1 Outerard 19 n.w.

WESTPORT 600 c. 402 l.

- 3 Westport in 1 d. 1 m. 1 b. 7 o.
- 3 Ballins 32 n.w.s., 2 m. 1 s. 2 b. 1 o.
- 1 Castlebar 11 n.w., 2 s.

TUAM 652 c. 366 l.

- 1 Tuam in 1 m. 1 b.
- 1 Dunmore 12 n.w.s.
- 1 Shrule 16 w., 1 m. 1 b.
- 1 Ballinrobe 23 w.n.w., 1 m. 1 b. 1 o.
- 1 Clare 20 n.n.w., 1 o.

LIMERICK.

400, 6½ days 238 miles; 9½ days 255 miles. Ex. 50,242 Q. R. 5619.

ENNIS 694 c. 640 l.

- 1 Ennis in 1 m. 1 b.
- 1 Sixmilebridge 16 n.e., 1 p.
- 1 Ennistimon 20 w.
- 1 Kilrush 27 s.w.

LIMERICK 1316 c. 1216 l.

- 6 Limerick in 1 d. 6 m. 2 b.
- 1 Tipperary 25 s.e.

CHARLEVILLE 1230 c. 1099 l.

- 1 Charleville in.
- 1 Kilmallock 6 s.
- 1 Mallow 17 s.
- 1 Kanturk 20 s.
- 1 Rathkeale 20 s.w., 1 m.

LONDONDERRY.

400, 2nd clk, 120; 13 days 235 miles. Ex. 52,375 Q. R. 638.

STRABANE 642 c. 40 l.

- 1 Ballymagerry 4 n.e., 1 p.
- 1 Strabane in 1 m. 1 b.
- 1 Castlederg 11 s.w.
- 1 Newtown Stewart 11 s.e.
- 1 Stranorlar 15 s.

OMAGH 630 c. 44 l.

- 1 Lowerstown 18 s.w., 1 m.
- 1 Trillick 18 s.w.
- 1 Omagh in.
- 1 Gortin 10 n.

RAMELTON 595 c. 15 l.

- 1 Ramelton in 1 m. 1 b.
- 1 Milford 5 n.w.
- 1 Letterkenny 9 s.s.w.
- 1 Creeslough 20 n.w.
- 1 Dungloe 43 w.

BUNCRANA 469 c. 18 l.

- 1 Burt 16.
- 1 Bunrana in.

- 1 Carn 14.

- 1 Morville 29 n.w.s.

LONDONDERRY 497 c. 38 l.

- 5 Londonderry in 1 d. 3 m. 2 b.
- 3 Waterside in 1 d. 2 m.
- 2 Clooney 2 n.e., 1 d. 1 m.

NAAS.

12 days 210 miles; 16 days 272 miles.
Ex. 74,000 Q. R. 3600.

LEIXLIP 1506 c. 1399 l.

- 1 Naas 18 s.w.
- 1 Clondalkin 6 s.e., 1 p.
- 1 Saggard 11 s.e., 1 p.
- 1 Leixlip in 1 d. 1 p.
- 2 Maynooth 9 n.w., 1 d. 2 m. 1 b.

MONASTEREVEN 1116 c. 984 l.

- 2 Monastereven 1 d. 1 m. 1 b.
- 1 Edenderry 15 n.
- 1 Mountmelick 15 w., 3 m. 1 b.
- 1 Athy 15 s.e., 2 m.

CARLOW 600 c. 1034 l.

- 2 Carlow in 11 m. 1 b.
- 1 Tullow 12 s.
- 1 Baltinglass 18 n.e.
- 2 Bagnalstown 12 s., 7 m.
- 1 Leighlin Bridge 8 s., 6 m.

KILKENNY 299 c. 756 l.

- 2 Kilkenny in 3 m. 1 s. 2 b.
- 1 Freshford 10 n.e.
- 1 Callan 12 s.

NEWRY.

400, 12 days 205. Ex. 56,000 Q. R. 2200.

ARMAGH 1196 c. 223 l.

- 2 Armagh in 1 m. 1 p. 1 o.
- 1 Middleton 10 n.w.
- 1 Portadown 12 n.e., 1 m. 1 b.
- 1 Lurgan 17 n.e., 2 m. 2 b.
- 1 Tandragee 16 s.

BALLYGAWLEY 567 c. 209 l.

- 3 Ballygawley in 1 d. 3 m. 1 b.
- 1 Monaghan 18 s.w., 1 m. 1 b. 2 o.
- 1 Dungannon 14 n.e., 1 m. 1 p.
- 1 Donaghmore 14 n.e., 1 m. 1 b.

DOWNPATRICK 595 c. 155 l.

- 1 Downpatrick in 1 d. 2 m. 1 b.
- 2 Saul 2 n., 1 d.
- 1 Crossgar 7 n.w.
- 1 Castledwellan 12 s.w.

NEWRY 952 c. 173 l.

- 2 Newry in 1 d. 1 m. 1 b. 2 o.
- 1 Rathfriland 11 n.e.
- 1 N. T. Hamilton 12 s.w.
- 1 Warrenpoint 7 s.e.

SLIGO.

400, 11 days 249 miles; 13 days 338 miles. Ex. 20,807 Q. R. 2833.

BALLYSHANNON 1038 c. 66 l.

- 1 Enniskillen 29 s.e., 1 m. 1 b.
- 2 Ballyshannon in 1 d. 2 m. 1 b.
- 1 Donegal 15 n.

CARRICK-ON-SHANNON 1179 c. 44 l.

- 1 Ballinamore 19 n.e.
- 1 Mohill 12 n.
- 1 Carrick-on-Shannon in
- 1 Ballaghaderreen 26 w.

SLIGO 871 c. 72 l.

- 1 Manorhamilton 15 n.e.
- 1 Ballymote 7 s.
- 2 Sligo in 1 d. 3 m. 4 s. 2 b.

WATERFORD.

10 days 178 miles; 11 days 158 Ex.
84,000 Q. R. 4500.

CLONMEL 1220 c. 91 l.

- 1 Clonmel in 1 m. 1 b.
- 3 Marlfield 3 w., 1 d. 1 m.
- 1 Cloghan 15 w., 1 m. 1 b.
- 2 Holycross 26 w., 1 d. 1 m.

WATERFORD 1462 c. 108 l.

- 4 Waterford in 2 m. 2 b.

- 1 Carrick-on-Suir 16 w., 2 m. b.
- 1 Dungarvan 28 s., 1 m. 1 b.

WEXFORD.

8 days 200 miles. Ex. 84,000 Q. R. 3800.

NEW ROSS 578 c. 450 l.

- 1 Graigne 20 n.w., 2 m.
- 1 Thomastown 23 w.
- 3 New Ross in 1 d. 3 m. 2 b.

WEXFORD 890 c. 340 l.

- 6 Wexford in 1 d. 30 m. 3 b.

GOREY 617 c. 580 l.

- 1 Newtownbarry 24 s.w.
- 1 Gorey in 1 m.
- 1 Carnew 12 w., 1 s.
- 1 Arklow 12 n.

ENNISCORTHY 515 c. 377 l.

- 2 Enniscorthy in 9 m. 1 b.
- 1 Taghmon 16 s.w.
- 1 Castlebridge 12 n.e., 2 m.

PART II.

DUTIES AND REGULATIONS.

No. 1.

GENERAL REGULATIONS.

Commissioners and Officers.

HER Majesty may appoint Commissioners of Excise, not exceeding thirteen, who shall hold office during her Majesty's pleasure, 7 & 8 G. 4, c. 53, s. 1. To be called "the Commissioners of Inland Revenue," 12 & 13 V. c. 1, s. 1, and the Commissioners hereafter appointed to be Commissioners of Inland Revenue, s. 2. Three Commissioners to constitute a board, with power to act throughout the United Kingdom, but subject to the control of the Treasury, 7 & 8 G. 4, c. 53, s. 2; 4 & 5 W. 4, c. 51, ss. 1, 2; 12 & 13 V. c. 1, ss. 3, 4.

The Commissioners to appoint officers (who are to give security if they receive money, 4 V. c. 20, s. 3), and to pay them such salaries as the Treasury shall direct; but the number of officers to be subject to the regulation of the Treasury, 7 & 8 G. 4, c. 53, ss. 4, 5; 12 & 13 V. c. 1, ss. 3, 15; and see as to the Receiver General and Accountant General &c., ss. 6—9. Every officer to make declaration of allegiance and office as follows:

"I, A B do sincerely and solemnly declare, that I will bear true allegiance to Her Majesty, and will execute the office of _____ to which I am appointed, truly and faithfully, without favour or affection; and that I will from time to time true account make and deliver to such person or persons as shall be duly appointed to receive the same; and that I will not take any fee or reward in or for the execution of the said office, from any other person than her Majesty or those whom her Majesty shall appoint in that behalf" 7 & 8 G. 4, c. 53, s. 7; 5 & 6 W. 4, c. 62 ss. 2, 3.

No Commissioner or Officer to be a Member of Parliament, or interfere in Elections, ss. 8, 9. No Officer to deal in goods subject to the Excise Laws, s. 10. The Commissioners and Officers exempt from serving in parish offices, or on juries, or in the militia, s. 11, and also from taking parish apprentices, 4 & 5 W. 4, c. 51, s. 3. But keepers of Excise offices not to be deemed Officers, 4 V. c. 20, s. 4. Persons employed in the Excise, not to take money or reward or enter into collusive agreements, 7 & 8 G. 4, c. 53, ss. 12, 13. No action to be brought against an Officer without notice &c., ss. 114—119.

The following are the amounts of Superannuation allowance, which the Treasury are authorised to grant under 4 & 5 W. 4, c. 24.

If the Officer entered the Service before the 5th August 1829.		If the Officer entered the Service after the 4th August 1829.	
Years of Service.	Proportion of Salary.	Years of Service.	Proportion of Salary.
10	15	10	17
15	20	17	24
20	25	24	31
25	30	31	38
30	35	38	45
35	40	45 and upwards . .	52
40	45		
45	50		
50 and upwards . .	55		

And none to exceed this amount except under special circumstances to be ordered by the Treasury, 4 & 5 W. 4. c. 24. s. 17.

Entry of Traders' Premises, &c.

Every Excise trader required to make entry, is to deliver such entry to the surveying Officer, who shall copy the same into the "General Entry Book" for the Division, 4 & 5 W. 4, c. 51, s. 5. No entry to be legal except in the name of the real owner, but the visible owner to be liable notwithstanding, 7 & 8 G. 4, c. 53, s. 20. But four managers of a Joint Stock Company, 4 V. c. 20, s. 6, and married women may, in certain cases, be permitted to make entry, s. 7. Not more than one entry to be in force for the same premises at the same time, 4 & 5 W. 4, c. 51, s. 8; unless the entered trader absconds, &c., s. 9. Places and Utensils mentioned in any entry to be distinguished by particular letters or numbers, and fixed pipes to be painted, 7 & 8 G. 4, c. 53, s. 21. Penalty for using places or utensils without entry, 4 & 5 W. 4, c. 51, ss. 8, 7; and forfeiture of goods found therein, 4 V. c. 20, s. 5. An entry may be proved without the attesting witness; and places and utensils not in the general entry book to be deemed unentered. Not necessary to produce an entry, in order to prove a person to be an Excise trader, 7 & 8 G. 4, c. 53, s. 19.

Licenses.

Licenses, under the general Licensing Act, to contain certain particulars, 6 G. 4, c. 81, s. 7. Licenses taken out by brewers, and distillers, and by publicans as retailers of beer, wine, spirits or sweets, expire on 10th October annually; all others (except certain trades not within the Act) expire on the 5th of July, s. 16. If a license be taken out by a beginner in any part of a year less than three quarters, a proportionate part of the duty only is payable, ss. 17, 18. One License is not sufficient for different sets of premises, except Auctioneers, or Maltsters, s. 10. In case of fire, &c., the license may be transferred to another house, s. 11; and in case of death or removal, the executors, wife, child, or assignee, may be authorised to continue the business, s. 21. Publicans' Licenses, subject to the granting and continuance of the Magistrates' certificate, ss. 13, 21, 22, 23. Licensed persons to put up their names and business, s. 25. Penalty on carrying on trade without license, s. 26.

The Magistrates' Alehouse Licensing Act for England, is 9 G. 4, c. 61; and for Scotland, 9 G. 4, c. 58.

Survey and Collection of Duties.

Officers and their assistants may enter any building or place used for carrying on any Excise trade, and inspect and take account of all matters appertaining to such business; and such Officers are to charge the Duty, and make a return to the Board (giving in certain cases a copy), which return shall be deemed a charge of such duty, 7 & 8 G. 4, c. 53, s. 22. Specimen books may be left and entries made therein, s. 23. Officers not to be hindered or obstructed, s. 24. Duties to be paid at such time and place as shall be appointed, or upon demand, under a penalty of double duty, 4 & 5 W. 4, c. 51, s. 11. But no person compelled to go further than the next market town, 7 & 8 G. 4, c. 53, s. 26. All goods subject to Excise duties, and all materials, machinery, vessels and implements used in the manufacture, to be liable for all duties, arrears and penalties incurred whilst in the possession of the trader, 4 V. c. 20, s. 24. Upon complaint of over charge or over payment, the Commissioners or two Justices may, in certain cases, order the duty to be returned, 4 & 5 W. 4, c. 51, s. 27; 4 V. c. 20, s. 33.

Permits.

No permit to be granted until a request note shall have been delivered, 2 W. 4, c. 16, ss. 5, 6. Penalty on sending out or delivering goods requiring permit without such permit, ss. 10, 11. The other general regulations relating to permits are all contained in the same Act.

Exporting goods on Drawback.

The person intending to export, to give notice to the Officer who is to attend and see the goods packed, 25 G. 3, c. 74, s. 12. The exporter to give notice of shipping and the Officer to attend, 56 G. 3, c. 104, s. 25. The exporter to give security and make declaration, 25 G. 3, c. 74, s. 13. No drawback to be allowed on unmerchable goods, 57 G. 3, c. 87, s. 10. Penalty on fraudulently depositing goods to obtain drawback, 4 & 5 W. 4, c. 51, s. 12.

Concealed goods, Unentered Manufactories, and Search Warrants.

"In case any goods or commodities for or in respect whereof any duty of Excise is or shall be imposed, or any materials, utensils, or vessels proper or intended to be made use of for or in the making of such goods or commodities, shall be removed, or shall be deposited or concealed in any place, with any intent to defraud his Majesty of such duty, or any part thereof, all such goods and commodities, and all such materials, utensils, and vessels respectively, shall be forfeited; and in every such case, and in every case where any goods or commodities shall be forfeited under this act, or any other act or acts of Parliament relating to the revenue of excise, all and singular the casks, vessels, cases, or other packages whatsoever, containing or which shall have contained such goods or commodities respectively, and every vessel, boat, cart, carriage, or other conveyance whatsoever, and all horses or other cattle, and all things used in the removal or for the deposit or concealment thereof respectively, shall be forfeited; and every person who shall remove, deposit, or conceal, or be concerned in removing, depositing, or concealing, any goods or commodities for or in respect whereof any duty of excise is or shall be imposed, with intent to defraud his Majesty of such duty, or any part thereof, shall forfeit and lose treble the value of all such goods and commodities, or the sum of one hundred pounds, at the election of the Commissioners of Excise or Customs, or the person who shall inform or sue for the same," 7 & 8 G. 4, c. 53, s. 32.

Persons found employed in unentered Excise manufactories, to forfeit £30, and may be immediately arrested and conveyed before a Justice; and on

conviction and nonpayment of the penalty, to be imprisoned for three calendar months, s. 33. Any person liable to arrest not being detained at the time may afterwards be arrested, 4 & 5 W. 4, c. 53, s. 25. Upon an Officer making oath of suspicion, two Commissioners or one Justice may grant a search warrant, 7 & 8 G. 4, c. 53, s. 34. Peace officers to assist, ss. 35, 37; 4 & 5 W. 4, c. 51, s. 16. Officers empowered to seize uncustomed goods, 7 & 8 G. 4, c. 53, s. 38. Punishment on rescuing seizures or violently resisting officers, ss. 39—43. Officers detecting private manufactories may be rewarded, 4 & 5 W. 4, c. 51, s. 14.

Seizures and Penalties.

Goods forfeited under the excise laws, may be seized by any officer or his assistant, 7 & 8 G. 4, c. 53, s. 64. Penalties and forfeiture to be distributed between the Queen and the informer, 7 & 8 G. 4, c. 53, s. 102. But "no part of any penalty or forfeiture incurred under or by virtue of any Act of Parliament, relating to the Revenue of Excise to be hereafter recovered, shall be distributed or paid to any officer or officers of excise; but all (if any) parts of such penalty or forfeiture which would have been payable to any officer of excise, if this act had not been passed, shall be deemed and taken to have been recovered to the use of her Majesty, her Heirs, or Successors," 11 & 12 V. c. 121, s. 28. See further as to seizures and penalties, 7 & 8 G. 4, c. 53, ss. 69, 70, 94, 100—112; 4 & 5 W. 4, c. 51, s. 13; 4 V. c. 20, s. 32. And as to seizures and penalties in Ireland, 1 & 2 W. 4, c. 55.

Summary Proceedings.

All Penalties and Forfeitures incurred under any Act relating to the Revenue of Excise shall be recovered and applied as directed by this Act, 7 & 8 G. 4, c. 53, s. 128. See also the amended Acts, 4 & 5 W. 4, c. 51; 4 V. c. 20. Penalties under Post Horses Acts and Stage Carriage Acts may also be prosecuted under the General Laws of Excise. See 6 & 7 W. 4, c. 45; 10 & 11 V. c. 42; 11 & 12 V. c. 118, s. 2, and Board's Order, 4th December, 1848.

No legal proceedings (except on immediate arrest) to be commenced, unless by order of the Commissioners, and in the name of an officer or of the Attorney-General, 7 & 8 G. 4, c. 53, s. 61. As to seizures under the Customs laws, see 4 & 5 W. 4, c. 51, s. 28; and as to joint prosecutions, see 7 & 8 G. 4, c. 53, s. 70. For any excise penalty or forfeiture incurred, an information may be exhibited before a Justice of the Peace, and upon appearance or proof of summons, before two Justices, the facts to be examined into, and judgment given. And no objection to be taken on account of distinct commissions of peace, 7 & 8 G. 4, c. 53, s. 65. Information to be exhibited within four calendar months. Notice to be given within a week afterwards. Summons to be served ten days before the hearing, except for double duty, when twelve hours' notice is sufficient. Service need not be personal, 4 & 5 W. 4, c. 51, s. 19. Justices to proceed to hearing and judgment without regard to defects in form, 7 & 8 G. 4, c. 53, s. 73. Witnesses summoned to appear and give evidence, s. 74. If a defendant be in prison, the summons may be delivered to the gaoler, s. 77. Any officer may conduct the prosecution in the absence of the informer, 4 & 5 W. 4, c. 51, s. 22. As to the proof of being an Excise Officer, see 7 & 8 G. 4, c. 53, s. 17; proof of Excise Entries, s. 19; proof of Averments in Information, s. 71; proof of Payment of Duties, s. 76. Proofs of Board Orders, s. 72. The Justices, on hearing, may mitigate any penalty to one-fourth, s. 78; except the penalty of double duty, and on immediate arrest, 4 & 5 W. 4, c. 51, s. 20. And the Board may further mitigate, or entirely remit the penalty, 7 & 8 G. 4, c. 53, s. 78.

Persons aggrieved by judgment of Justices may appeal to the Quarter Sessions, 7 & 8 G. 4, c. 53, s. 82. Notice of Appeal to be given, and deposit, in certain cases, to be made, s. 83. If there shall not be twenty days between giving notice and the next session, the Appeal to be to the following Session, 4 & 5 W. 4, c. 51, s. 23. Notice of the time and place of hearing the Appeal to be given seven clear days before it is heard, 4 V. c. 20, s. 30. Proceedings on the hearing, 7 & 8 G. 4, c. 53, ss. 84, 85; 4 & 5 W. 4, c. 51, s. 24. On judgment, warrants to be granted for levying the penalties on defendant's goods, ss. 86, 87, 88, 89. When sufficient distress cannot be found, a body warrant may be issued, s. 90.

No. 2.

DUTIES AND SPECIAL REGULATIONS, ALPHABETICALLY ARRANGED.

Auctions.

License.—For selling by auction in the United Kingdom, 10*l.* per annum. 8 V. c. 15, s. 2.

Regulations.—Penalty on carrying on trade as an auctioneer without license, 100*l.*, s. 4. For selling by auction, and not producing his license on demand, or depositing 10*l.*, the auctioneer may be arrested, and conveyed before a magistrate, who may commit him to gaol for one calendar month, s. 6.

Beer.

Duty on sugar used by any brewer of beer for sale in brewing, 1*s.* 4*d.* per cwt., 13 and 14 V. c. 67, s. 3.

License to be taken out annually by the following traders, under 6 G. 4, c. 81; and see 13 & 14 V. c. 67, ss. 6, 7:—

Brewers of table beer only for sale, not exceeding—

	£	s.	d.		£	s.	d.
20 barrels . . .	0	10	6	100 barrels	1	11	6
50 " . . .	1	1	0	exceeding 100 "	2	2	0

Brewers of beer, other than table-beer for sale, not exceeding—

	£	s.	d.		£	s.	d.
20 barrels . . .	0	10	6	7,500 barrels	11	16	3
50 " . . .	1	1	0	10,000 "	15	15	0
100 " . . .	1	11	6	20,000 "	31	10	0
1000 " . . .	2	2	0	30,000 "	47	5	0
2000 " . . .	3	3	0	40,000 "	63	0	0
5000 " . . .	7	17	6	exceeding 40,000 "	78	15	0

Brewers for sale by retail, not to be consumed on the premises, 5*l.* 10*s.* 3*d.*; Sellers of beer only, not being brewers, 3*l.* 6*s.* 1*½d.*; Beer retailers (publicans), whose premises are rated under 20*l.* per annum, 1*l.* 2*s.* 0*½d.*; at 20*l.* or upwards, 3*l.* 6*s.* 1*½d.*. The following are granted under 4 & 5 W. 4, c. 85:—Retailers of beer, cider, and perry, to be drunk on the premises (England only), 3*l.* 6*s.* 1*½d.*; not to be drunk on the premises, 1*l.* 2*s.* 0*½d.*. The following is granted under 1 W. 4, c. 64:—Retailers of cider and perry only, 1*l.* 2*s.* 0*½d.*. The whole of the preceding license duties include the 5 per cent. additional granted by 3 V. c. 17.

Regulations.—Brewers are to make entry of their premises and mash-tuns, and are prohibited from using any malt or hops, except such as are

taken from the rooms so entered : and officers are to be permitted to visit and survey them, 1 W. 4, c. 51, ss. 15, 16 ; 7 & 8 G. 4, c. 52, ss. 54, 55.

Before putting any water upon his malt for brewing, the brewer is to enter in an excise book or paper, the date of such entry, the quantity of malt intended to be used, and the date of the brewing ; and he is not to remove any such malt from the mash-tun after all the worts have been drawn off, until the officer shall have gauged the same, or within an hour after the time specified ; nor to mix worts with any yeast, until the officer has taken a sample thereof, or within one hour after the time specified in the notice, 1 & 2 G. 4, c. 22, ss. 1—3.

Brewers may use sugar in brewing, 10 V. c. 5, s. 1 ; but in such case they must enter in a book, to be delivered by the officer, the true quantity of all sugar used, s. 5 ; 13 & 14 V. c. 67, s. 5. Brewers using sugar to pay their license duty on the quantity used ; 50lbs. of sugar being deemed to produce 1 barrel of beer, 10 V. c. 5, s. 6.

Brewers, except as above, are not to use any ingredient but malt, hops, and water, under a penalty of 200*l.* ; and any person knowingly selling adulterating articles of any kind to a brewer, dealer, or retailer, is liable to a penalty of 500*l.*, 56 G. 3, c. 58, ss. 2, 3 ; and see as to Ireland, 7 & 8 G. 4, c. 52, s. 64, &c.

No brewer is to keep any unmalted grain in his entered premises, or in any mill connected with them, under a penalty of 200*l.*, 1 W. 4, c. 51, s. 17.

Beer retailers are prohibited from mixing adulterating ingredients with beer, 1 W. 4, c. 64, s. 13 ; and from permitting wine or spirits to be consumed on their premises, 4 & 5 W. 4, c. 85, s. 16 ; or being on their entered premises, 3 & 4 V. c. 61, s. 10.

The police regulations respecting public-houses are contained in 9 G. 4, c. 61, for England ; and in 9 G. 4, c. 58, for Scotland.

The licenses of beer retailers, not being publicans, are granted on the certificate of a certain number of householders, and on a bond being entered into with sureties, 1 W. 4, c. 64, ss. 1, 2 ; 4 & 5 W. 4, c. 85, ss. 1—3 ; 3 & 4 V. c. 61.

Beer, in respect of the malt used in brewing, is entitled on exportation to a drawback.—*Vide Malt, infra.*

Coffee, Tea, Cocoa-Nuts, Chocolate, and Pepper.

License to be taken out annually by every dealer in coffee, tea, cocoa-nuts, chocolate, and pepper, 1*l.*, 6 G. 4, c. 81 ; and 6*½d.* additional by 3 V. c. 17.

Regulations.—Every dealer in coffee, tea, cocoa-nuts, chocolate, or pepper, is to make entry of his premises, which are to be open to the inspection of the officers, 10 G. 1, c. 10, ss. 10, 12. See, also, 9 G. 4, c. 44, ss. 1, 4 ; and *Board's Orders, dated 26th July, 1828, and 1st March, 1836.*

For the penalties for adulterating Coffee or Cocoa, see 43 G. 3, c. 129, s. 5 ; Tea, 11 G. 1, c. 30, s. 5 ; 4 G. 2, c. 14, s. 11 ; 17 G. 3, c. 29, ss. 1, 3 ; Pepper, 59 G. 3, c. 53, s. 22. Set out in the "Adulteration Paper."

Cider (see Beer).

Game.

License to kill game in Ireland, 3*l.* 8*s.* per annum, 56 G. 3, c. 56 ; 5 & 6 V. c. 81.

Regulations.—Penalty on uncertified persons keeping dogs for killing game, 5 & 6 V. c. 81, s. 5. Certificates to be produced on demand, s. 8.

Hackney Carriages.

Duty on hackney carriages in London per week, 10*s.*, 1 & 2 W. 4, c. 22.

License to be taken out in London to keep any hackney carriage, 5*l.* (*ibid.*)
The Regulations on which the duties are collected are contained in the same act. Duties transferred to the Excise, 10 & 11 V. c. 42.

Hops.

Duty on hops cured and made fit for use in England, 2*d.* per lb., 45 G. 3, c. 94; with 5 per cent. additional, 3 V. c. 17.

Regulations.—Every grower of hops is required before the 1st of August in each year to make entry of his hop grounds; and before he begins to pick any hops, to make entry of his out-houses and rooms, 9 Anne, c. 12, ss. 6—8. He is likewise required to give the officer *twenty-four* hours' previous notice in the first week, and forty-eight hours' afterwards, of the day and hour when he intends to begin to bag his hops; and a like notice for weighing them, 9 Anne, c. 12, ss. 10—12; 6 G. 1, c. 21, s. 25; and 39 & 40 G. 3, c. 81, s. 6.

Before putting hops into any bag or pocket, the grower is to mark his name, and the parish, &c., thereon, 39 & 40 G. 3, c. 81, s. 2; 48 G. 3, c. 134, s. 1; and 54 G. 3, c. 123, s. 1. All hops are to be cured and bagged within six weeks after having been picked, 9 Anne, c. 12, s. 9.

No officer inferior to a supervisor is allowed to weigh hops between 5 P.M. and 4 A.M., 39 & 40 G. 3, c. 81, s. 7. In weighing the hops 10 per cent. is deducted from the gross weight for the tare of the package, 9 Anne, c. 12, s. 13. After weighing, the officer is to mark upon each bag and pocket the progressive number, gross weight, and year of charge; and the grower is to keep them unmixed with others for *twelve* hours, unless they shall be sooner reweighed by the supervisor, 39 & 40 G. 3, c. 81, ss. 4, 5. Hop-growers to keep just scales and weights, and permit officers to use them, 6 G. 1, c. 21, s. 26.

The weight of hops taken account of by the officer to be returned, and become a charge to the grower, 9 Anne, c. 12, s. 11; 6 G. 1, c. 21, s. 28.

The duties are payable, one moiety on the 1st of March next after the charge, and the remainder on the 1st of October following, 1 & 2 W. 4, c. 53, but see "general instructions."

A grower is not to use a bag a second time, nor put hops of different qualities into the same bag, or alter them, 7 G. 2, c. 19, s. 2; 54 G. 3, c. 123, s. 2; 9 Anne, c. 12, s. 23. The weight of the bag must be in proportion to the weight of the hops therein, 39 & 40 G. 3, c. 81, s. 3. As to pickers carrying off hops, see 9 Anne, c. 12, s. 18. As to the removal of British hops to Ireland, see 26 G. 3, c. 5.

Drawback on hops exported to the Isle of Man, 2*d.* per lb., 45 G. 3, c. 99; and to foreign parts, 2*d.* per lb., 1 & 2 G. 4, c. 100, and 5 per cent. additional, 3 V. c. 17.

Malt.

Duty on malt made in the United Kingdom 2*s.* 7*d.* per bushel, 6 G. 4, c. 58, and Treasury Warrant of 11th of May, 1826; and on malt, made from bear or bigg only in Scotland or Ireland for consumption there, 2*s.* per bushel, 6 G. 4, c. 58; 11 G. 4, c. 31; with 5 per cent. additional in both cases, 3 V. c. 17.

License to be taken out annually by maltsters in proportion to the quantity made, as follows, 6 G. 4, c. 81:—

	£	s.	d.		£	s.	d.
Not exceeding 50 qrs. .	0	7	10½	Not exceeding 400 qrs. .	3	3	0
" 100 " .	0	15	9	" 450 " .	3	10	10½
" 150 " .	1	3	7½	" 500 " .	3	18	9
" 200 " .	1	11	6	" 550 " .	4	6	7½
" 250 " .	1	19	4½	Exceeding 550 " .	4	14	6
" 300 " .	2	7	3	Beginners (and a surcharge)	7	10½	
" 350 " .	2	15	1½	Not exceeding 5 qrs. . .	2	7½	

The whole of the preceding *licensæ* duties include the 5 per cent. additional granted by 3 V. c. 17.

The following are granted by 5 V. sess. 2, c. 30 :—

Malt roasters £20 | Dealers in roasted malt . . £10

Regulations.—Every person making malt is required to make entry of his rooms, places, and utensils, 7 & 8 G. 4, c. 52, s. 1; and every *cistern* for steeping more than eight bushels at any one time is to be rectangular, and of no greater depth than forty inches, with an even bottom, and no more inclination for the drip than half an inch in each foot; and to be so placed as to be easily and conveniently gauged, 7 & 8 G. 4, c. 52, ss. 2, 3; 11 G. 4, c. 17, s. 3; and before being used, a certificate of examination must be obtained from the supervisor, 7 & 8 G. 4, c. 52, s. 3; and every *couch frame* is to be rectangular, and permanently constructed, 7 & 8 G. 4, c. 52, s. 5.

Every maltster to give to the officer twenty-four hours' notice of the particular hour when he intends to wet grain, 11 G. 4, c. 17, s. 7, and 1 V. c. 49, s. 2; which must not be at any other time than between 8 A.M. and 2 P.M., 7 & 8 G. 4, c. 52, s. 31; and having begun to wet, he must cover the whole of the grain with water within *three* hours after the time for beginning; and must continue the same so covered *forty* hours; except that, on notice, he may draw off the water, for not exceeding an hour, once in that time; and fresh grain is not to be added after an account has been taken by the officer, 11 G. 4, c. 17; ss. 7, 13, 14; 7 & 8 G. 4, c. 52, s. 36.

Corn is not to be taken out of the *cistern*, so that it cannot be gauged in the *couch-frame*, under a penalty, s. 31; but must be emptied out between 7 A.M. and 4 P.M., s. 27; and not before the day on which ninety-six hours expired from the last preceding emptying, s. 30. And when two or more *cisterns* are used in the same malt-house, they must all be emptied within *three* hours after the emptying begins, s. 29.

Corn emptied from the *cistern* is to be put into the *couch-frame* (one such frame being allowed to be used for two or more *cisterns* in the same malt-house), but not to be laid deeper than thirty inches, and to be laid flat and level, and kept in the *couch-frame* *twenty-six* hours at least, s. 32; and if the corn shall not be gauged within that time, any gauge taken before the end of *thirty* hours is to be deemed a *couch-gauge*, and such corn not to be entitled to the allowance as a floor-gauge, s. 32; 11 G. 4, c. 17, s. 16; but see General Order of 22nd Feb., 1849.

No maltster is to tread or force together any corn in the *cistern* or *couch-frame*, and an officer, suspecting it to be so trodden or forced, may have it turned out and returned; and if any increase shall be found in the gauged quantity, after being again laid level, in a greater proportion than 5 per cent. within *eight* hours, or 6 per cent. after that time and within *sixteen* hours, or 7 per cent. afterwards, a penalty is incurred, 7 & 8 G. 4, c. 52, s. 33; 1 V. c. 49, s. 5.

After corn has been emptied out of the *cistern*, it is not to be wetted or sprinkled before the end of twelve days, or 288 hours, 7 & 8 G. 4, c. 52, s. 35; unless all the corn on the floor of the malt-house shall have been steeped fifty hours; in which case a floor may, on notice, be sprinkled at the end of six days, or 144 hours, 1 V. c. 49, s. 7.

No maltster to have at one time more than six floors, including the *couch-frame* and kiln, in operation at the same time, and worked in the same *cistern* or *couch-frame*; but floors may be divided for working separately, 7 & 8 G. 4, c. 52, s. 36; 1 V. c. 49, s. 10. And all floors are to be levelled, and laid in succession according to seniority of age, 11 G. 4, c. 17, s. 19; 7 & 8 G. 4, c. 52, s. 37. A maltster is not to mix corn of different wettings or steepings, either on the floor or kiln, s. 38; nor to wet or damp corn after being taken off the kiln, s. 39; nor fraudulently to conceal malt, or corn making into malt, from the sight of the officer, s. 40; nor to remove malt

before it has been charged with duty; and no person is to receive malt, knowing the same to have been so removed, s. 41.

The following allowances are to be made upon the gauges of corn or grain, making into malt, viz.: Upon every gauge taken in the cistern, or couch-frame, an allowance of $1\frac{1}{4}$ bushels in every 100; and upon every gauge taken on the floor or kiln, after the expiration of twenty-six hours, if a previous gauge has been taken, or thirty hours if no such previous gauge has been taken, an allowance of *one-half*; and the duty is to be charged upon the best gauge after such allowances have been made, 1 V. c. 49, s. 9; and the officer is to make a return of such duty every six weeks, and the same is to be paid and cleared off within six days after the return, unless the maltster shall have entered into bond with sufficient sureties for the due payment of his duties within eighteen weeks after the return, 7 & 8 G. 4, c. 52, s. 7; 11 G. 4, c. 17, s. 26. But maltsters for distilling from malt only in Scotland and Ireland are not allowed the long credit, whether bond has been given or not, s. 27.

If any maltster's servant shall, with intent to injure his master, commit any offence against the malt acts, he may be arrested, and on conviction, committed to gaol; but the maltster is liable to the penalty, unless he prosecute and produce a certificate of conviction, 7 & 8 G. 4, c. 52, s. 46; 11 G. 4, c. 17, s. 35.

In case of loss or damage of malt by fire or accident, an allowance of the duty is, under certain regulations, made to the proprietor, 7 & 8 G. 4, c. 52, s. 76; 11 G. 4, c. 17, s. 37.

Maltsters may dry raw grain on a malt kiln, on giving twenty-four hours' notice, 11 G. 4, c. 17, s. 2; 2 W. 4, c. 29, s. 14; 1 V. c. 49, s. 2.

Makers of malt in Scotland or Ireland from bear or bigg only, are subject to the same regulations as other maltsters. They are also to express in their entry, that they intend to make malt from *bear* or *bigg* only. 3 G. 4, c. 30, s. 2. And the same premises and utensils are not to be entered for making barley malt, s. 6; but on the contrary, all *bear* and *bigg* malt is to be kept separate from barley malt until it is put into the mash-tun, s. 2. A certificate is to accompany *bear* or *bigg* from the grower to the maltster, s. 7; and when received it must be kept separate from all other *bear* or *bigg* for twenty-four hours, s. 9; and must not be steeped during that time, or until it has been examined by the officer, s. 10, who is authorized to take samples, s. 11.

These regulations are extended to Ireland by 11 G. 4, c. 31.

As to private malting in Scotland and Ireland, see 1 & 2 W. 4, c. 55; and see "Spirits," *infra*.

As to *malt roasters* and *dealers* in roasted malt, see 5 V. sess. 2, c. 30.

Drawback on beer, in consideration of the malt used, 5s. per barrel, if the specific gravity of the worts used in brewing was between 1.054 and 1.081; and 7s. 6d. per barrel if the specific gravity was not less than 1.081; with 5 per cent. additional, 10 V. c. 5, s. 7. Regulations for exporting the goods and obtaining the drawback, 1 W. 4, c. 51, ss. 9—14; 10 V. c. 5, ss. 8—11.

Paprr.

Duty on paper, glazed paper, sheathing paper, button-board, mill-board, paste-board, and scale-board, made in the United Kingdom, $1\frac{1}{2}$ d. per lb., 2 & 3 V. c. 23, s. 1; with 5 per cent. additional, 3 V. c. 17.

License to be taken out annually by paper-makers, 4l., 6 G. 4, c. 81, s. 2; with 4s. additional, 3 V. c. 17.

Regulations.—Every maker of paper, &c., to make entry of his premises and utensils, which are to be marked with particular letters, 2 & 3 V. c. 23, ss. 3, 4. Every paper-mill to be distinguished in the officer's books by a particular number, s. 5. Two mills not further apart than a mile, when the paper is removed from one to the other to be finished, may, with the Board's

permission, be worked as one mill, under one entry, and one license, s. 6. Officers are to be at liberty to survey the premises, s. 7.

The commissioners are to provide stamps for denoting the charge of duty, s. 8. They are also to issue paper labels to the supervisors; and the trader is to be supplied with such labels within four days after delivering to the officer a request note, upon which a receipt is to be given for the same; and such labels are to be delivered up at any time to any supervisor or superior officer, s. 9.

All paper, &c., to be made up into reams, half-reams, or parcels, and to be inclosed in wrappers, with a label firmly fixed on the top or such other part thereof as the Board shall direct, and then secured with a string; and when tied up, the maker is to mark on the label the description and contents of the ream, &c., s. 10. A ream is to consist of 20 quires of 24 sheets each, or 40 half-quires; and a half-ream of 10 quires or 20 half-quires; except that for printing, the ream may be 516 sheets, and the half-ream 258 sheets; and except the outside quires of any ream, which may be from 20 to 24 sheets. A parcel of glazed paper, &c., to consist of even dozens, not less than 24 nor more than 72 sheets in each, s. 11. But parcels less than a ream of paper not weighing less than 20lbs. may be made up, if necessary, on the number of sheets being marked on the label, s. 12.

Paper may be cut at the edges and made into quires without folding, provided every quire be separated by a slip of coloured paper, s. 13. The weight of every ream, half-ream, or parcel of paper or mill-board, &c., is to be written thereon, s. 14.

Twenty-four hours' notice in a town, and forty-eight hours' elsewhere, to be given of the maker's intention to weigh paper, s. 15. At the time specified in the notice, the proper officer is to attend and weigh the paper, and charge and stamp it, s. 16. Under certain regulations, paper may be sent out in single sheets on the rollers, on which the same may be received from the machine, without cutting or making up, s. 17. Paper, &c., after being weighed, to be kept separate for twenty-four hours, unless sooner reweighed, s. 18. If the paper-maker shall desire paper, &c., not to be reweighed on a Sunday, it may be kept over until Monday, s. 19. (But see General Order of 25th January, 1851.) The maker to keep just scales and weights, and allow the officer to use them, s. 20. And the maker, when required, is to bring the paper to be weighed, and assist the officer in weighing, s. 21. In weighing for charge of duty, the turn of the scale to be given in favour of the crown, and in lieu thereof *two* per cent. to be allowed to the traders, s. 22. Paper, &c., not charged, to be kept separate from charged paper, s. 23. And reams, &c., after being tied up, not to be opened or altered, s. 24.

An account of paper, &c., sent out from the mill, to be daily entered in a book by the maker, and such book to be open to the inspection of the officers, s. 25. Any ream, half-ream, or parcel, sent out without being tied up and labelled, to be forfeited, s. 26. Paper found different from the weight marked on the ream, half-ream, or parcel, by 5 per cent. if above 20lbs., or by 10 per cent. if under, to be also forfeited, s. 27. And any maker sending out paper, &c., before the duty is charged, to forfeit 300*l.*, s. 28.

Paper may be removed from one mill to another, to be sized and finished, on notice and certificate, s. 29. And paper charged with duty at another mill, or returned from a customer, to be marked returned, and notified by the officer, s. 30.

Makers of *paste-board*, not being paper-makers, to use duty-charged paper only, s. 31; and to produce to the officer all paper before making use of it, in order to its being taken account of, s. 32. Every maker, or his chief workman, to make a declaration every six weeks that no other than duty-charged paper has been sent out of the mill, s. 33. And at the end of every six weeks the officer is to make a return of the duty charged on every maker,

and the amount to be paid in six days afterwards, s. 34. In making up the charge against a *paste-board* maker, not being also a maker of paper, the duty charged on the paper used therein to be deducted, s. 35.

No person to carry on the business of a *stationer* at any mill, nor any maker to be a stationer within a mile of his mill, s. 36.

Stationers, printers, paperstainers, and makers of pasteboard, are prohibited from receiving paper in less quantities than an entire ream, half-ream, or parcel, and inclosed in legal wrappers; and no other person is to remove or receive it from a mill in less quantities than as aforesaid, s. 37. Every person on opening paper is to write across or otherwise deface the label, s. 38. And labels or wrappers which have been used are not to be returned to, or received back at a mill, s. 39; unless the paper be returned for not being approved of, s. 40. But any stationer, &c., having paper liable to seizure, and giving notice thereof to an excise officer, so as to cause its seizure, is, on its condemnation, to be paid the value thereof, s. 41.

Any person forging stamps, or counterfeiting labels, &c., to forfeit 500*l.* for every ream, &c., which is forfeited, s. 42; and any person altering the number or weight on the label, to forfeit 20*l.* per ream, &c., s. 43.

Allowances on paper used by hot-pressers, &c., 1½*d.* per lb.; and on paper used in printing Bibles, &c., at the University, 1½*d.* per lb., 2 & 3 V. c. 23, s. 1; and 5 per cent. additional, 3 V. c. 17. Such allowances to be granted under certain regulations, 2 & 3 V. c. 23, ss. 44—51.

Drawback on paper, &c., exported as merchandise, 1½*d.* per lb.; and on printed books, account books, &c., 1½*d.* per lb.; and on printed, painted, or stained paper exported, 2*d.* per lb., s. 1; and 5 per cent. additional, 3 V. c. 17. Such drawbacks to be granted under certain regulations, 2 & 3 V. c. 23, ss. 55—62.

If paper be lost by fire or wreck, the duty to be allowed, ss. 63, 64.

"Paper," except when otherwise expressed, is to include glazed paper, sheathing paper, button paper, &c., ss. 65, 66.

Passage-Vessels.

Licenses to be taken out by the Master or Commander of any passage-vessel, to retail foreign wine, strong beer, cider, perry, spirituous liquors, and tobacco, 1*l.*, 9 G. 4, c. 47; and 1*s.* additional, 3 V. c. 17.

The regulations under which the licenses are granted are contained in 9 G. 4, c. 47, and 4 & 5 W. 4, c. 75, s. 10.

Pepper (see Coffee, &c.)

Post Horses.

Duty on post horses let for hire in Great Britain for travelling post, for every mile, 1½*d.* per horse; to go no greater distance than 8 miles, 1*s.* 9*d.* or ⅔ of the sum charged; ditto, not to bring back any person, 1*s.* Let by the day, for every day not exceeding three, 2*s.* 6*d.*; exceeding three and not exceeding thirteen, 1*s.* 9*d.*; exceeding thirteen and not exceeding twenty-seven, 1*s.* 3*d.* or ⅓ of the sum charged, 2 & 3 W. 4, c. 120.

Composition for Hackney Carriages in towns (except in London); if drawn by two horses, 5*s.* per week, and if drawn by 1 horse, 3*s.* (*ibid.*)

Licenses to be taken out by every postmaster in Great Britain annually, 7*s.* 6*d.* (*ibid.*), and in Ireland 2*l.* 2*s.*, 55 G. 3, c. 19, and 11 & 12 V. c. 118; and in the latter case 5 per cent. additional, 3 V. c. 17.

Regulations.—Postmasters are to have the words "*licensed to let horses for hire*," painted on a sign-board, 2 & 3 W. 4, c. 120, s. 59. Their licenses are to expire on the 31st Jan. annually, s. 55; and may be acted on by representatives thirty days in case of death, &c., s. 56; but one license will only serve for one place, s. 58.

The Commissioners, or their officers, are to supply postmasters and toll-gate keepers with proper tickets, s. 61; and every postmaster who shall let any horse for hire, is to deliver a ticket properly filled up to the hirer, under a penalty, s. 62. No person to pay hire for more miles than is expressed in the ticket, s. 63. Persons using hired horses to deliver the tickets at the first toll-gate, and to receive check tickets, s. 64. The toll-gate keepers are to demand the tickets, and deliver the check tickets; and 1s. 9d. per horse to be paid to the toll-gate keeper on passing without the proper ticket, s. 65. Penalty on neglecting to deliver tickets, or falsely alleging hired horses to be their own, s. 66. Toll-gate keepers are to deliver the tickets received by them to the proper collectors, s. 67, for which they are to receive an allowance, s. 68. The Commissioners may erect gates in certain cases for the receipt of tickets, s. 69. When horses hired for 28 days or more, are returned within that period, the check ticket to be delivered up to the collector, s. 70. Postmasters are to account for tickets delivered to them s. 71. Penalty on forging ticket, £50, s. 72.

The Commissioners are to deliver to licensed postmasters forms of "Weekly Accounts," s. 73, in which an account of each hiring is to be inserted, s. 74. Entries are to be made on the day the horses are let, s. 75. The account is to be kept open for inspection, s. 76. At the time fixed in the notices for that purpose inserted in the "Weekly Accounts," postmasters are to deliver their accounts and pay the duty, ss. 77, 82. The postmaster to make a declaration to the truth of his account, s. 78. An allowance to be made to the postmasters of 3d. in the pound, s. 80.

Penalty on postmaster for wilful fraud, s. 81.

The post-horse duties were transferred from the Board of Stamps to the Board of Excise by 6 & 7 W. 4, c. 45, which vested all the powers of 2 & 3 W. 4, c. 120, in the commissioners and officers of excise. And see 11 & 12 V. c. 118, s. 2.

Railways (see *Stage Carriages*).

Soap.

Duty on hard Soap made in Great Britain, or brought from Ireland, 1½d. per lb.; and on soft soap 1d. per lb. 3 & 4 V. c. 49, s. 1; and 5 per cent. additional, 3 V. c. 17.

License to be taken out annually by every maker of soap for sale in the United Kingdom £4, 6 G. 4, c. 81, with 4s. additional, 3 V. c. 17.

Regulations.—Every soap-maker is to make entry of his premises and utensils, 3 & 4 V. c. 49, s. 3; and to mark and number the same, s. 4. Officers may enter and survey, s. 5; and the soap-maker, if required, is to provide sheds or watch-boxes for their accommodation, s. 6. Every soap-maker is to provide covers for his coppers and half-boil tubs, s. 7; and proper fastenings for securing the covers of his coppers, tubs, and vessels, which are to be kept under the officer's lock when not in use, s. 8. Coppers are not to have pipes or holes therein, s. 9; unless the soap be boiled by steam, in which case one continuous pipe may be used, s. 10.

Six hours' notice is to be given for unlocking coppers, between 6 A.M. and 6 P.M., and twelve hours for unlocking coppers at any other time; which notice is to be void, if not acted on within three hours of the time therein specified, s. 11; but the officer may open and inspect at any time, s. 12. Soap, &c., may be removed from one copper, &c., to another, for the purpose of repairs, under certain restrictions, s. 13; and materials may be removed from one copper to another in the officer's presence, a proper notice being first given, s. 14; and in case of accident, the materials may be removed on an immediate notice, s. 15. A supervisor or surveyor may direct a copper to be cleaned out for examination after a cleanse, s. 16. Covers, fastenings,

locks, and keys, to be altered and repaired, when required, at the expense of the soap-maker, s. 17, and penalties are incurred if access be gained to the coppers when secured, or if the fastenings are damaged, s. 18.

Six hours' notice to be given of cleansing soap, s. 19; and none to be cleansed between 8 P.M. in summer, or 7 P.M. in winter, and six in the following morning, s. 20. The frames for cleansing soap (except any in use before the passing of the Act), to be made of wood, iron, or slate; and to be of a rectangular shape, 45 inches long, and 15 broad, and of proper strength and thickness, s. 21. No frame to be made use of until the dimensions have been ascertained by the officers, and not afterwards to be altered, s. 22. No intermediate vessel to be used except palls, or a pan capable of containing an entire frame, s. 23.

Hard Soap to be cleansed to not less than the depth of 45 inches in the frame, s. 24; and where the cleanse shall not exceed three tons, the whole to be put into the frames in two hours; not exceeding six tons in three hours; and exceeding six tons, then within twenty minutes for each additional ton cleansed, s. 25. When, after a cleanse, any foul goods shall be left in the copper, the soap-maker is to return all the fob and skimmings, and add fresh materials, s. 26. All hard soap to be charged with duty by gauge, s. 27; and in gauging hard soap from the usual materials, 28 cubic inches, when hot, and 27·14, when cold, to be taken as a pound weight avoirdupois, s. 28. But in charging *mottled* soap one lb. in ten to be allowed, s. 29; provided such mottled soap be made of the usual materials, and cleansed within a given time, s. 30. And when soap is made in a high-pressure boiler, and not fitted, 26·76 cubic inches when hot, and 25·91 cubic inches when cold, to be a pound avoirdupois, s. 31. When earth or other materials are used in making hard soap 24·04 cubic inches when hot, and 23·30 cubic inches when cold, to be a pound avoirdupois, s. 32. The soap-maker is to deliver a declaration, whether the soap to be cleansed is made from ordinary materials, or has had earthy matter added to it, s. 33. And officers may take samples of the soap when cutting up, on paying for the same; and if within 48 hours it be found of a greater specific gravity than 1·05, or (if boiled in a high-pressure boiler and not fitted) than 1·08 (water being taken at unity; at a temperature of 62 degrees), to be deemed to be mixed with earthy matter, s. 34. Hard soap, if of the depth of 50 inches or less, to be cut up and removed within *six* days from a wooden frame, and within four days from an iron or slate frame. If deeper than fifty inches, within seven days from a wooden frame, and within five days from an iron or slate frame (Sundays exclusive), s. 35. And after the soap has been cut up, the scraps and parings to be returned into the copper, s. 36. Hard soap not to be sold or sent out in any other form than bars or parts of bars, s. 37.

Soft Soap to be cleansed only into barrels (256lbs.), half-barrels (128lbs.), firkins (64lbs.), or half-firkins (32lbs.), s. 38; and at the time of cleansing, the maker is to produce all the barrels, firkins, &c., properly tared, s. 39. When a soft-soap boiler shall contain less than 2560 lbs. weight, the whole to be cleansed within an hour; when less than 5120lbs. weight, within two hours; and when 5120lbs. weight or more, within three hours, s. 40. Soft soap to be weighed for the charge of duty within three days (Sunday exclusive) after being cleansed, and to be adjusted in the barrels, &c., s. 41. A supervisor or surveyor may reweigh at any time, s. 42; and makers of soft soap are to provide scales and weights, and assist the officers in using them, s. 43.

The officers are to make a return of the duty charged on each soap-maker weekly, or as the Commissioners shall appoint; which duty is to be paid within *six* days afterwards, under the penalty of double duty, s. 44.

Penalty on mixing water, &c., with soap after being charged, s. 45, and for concealing soap and materials, s. 46. The Commissioners may allow

experiments to be made in the process of making soap, under certain regulations, s. 47; and may also allow the use of new or improved utensils, although not made in conformity with the act, s. 48. Soap-makers are not to work on Sundays, except in cases specially provided for, s. 49. Officers may break up ground to search for private pipes and conveyances, s. 50.

Every person making or melting soap to be deemed a soap-maker, except certain perfumers, s. 51.

Perfumers to make entry with the excise, s. 52. *Candle-makers* and tallow-melters are also to make entry, and not to have alkaline lees in their possession, s. 53; and *lees* fit for soap-making not to be manufactured for sale, s. 54.

Entry to be made with the excise officers of soap brought from Ireland, s. 55, which must not be in packages less than 224lbs. each, s. 56.

Allowance on hard soap used in the manufacture of woollens $1\frac{1}{2}d.$ per lb.; soft ditto $\frac{1}{2}d.$ per lb.; on hard soap used in the manufacture of silks, flax, or cotton, $1\frac{1}{2}d.$ per lb.; soft ditto $\frac{1}{2}d.$ per lb. 3 W. 4, c. 16; 14 & 15 V. c. 59; and 5 per cent. additional by 3 V. c. 17. Such allowances to be made under the acts referred to, and 23 G. 3, c. 77; 3 G. 4, c. 25 (made perpetual by 7 G. 4, c. 49); 7 G. 4, c. 53, s. 4.

Drawback on hard soap exported to foreign ports or removed into Ireland, $1\frac{1}{2}d.$ per lb.; soft ditto $1d.$ per lb., 8 & 4 V. c. 49, and 5 per cent. additional, 3 V. c. 17; such drawback to be granted under certain regulations, 3 & 4 V. c. 49, ss. 57—68.

Spirits.

Duty on Spirits made in England, or imported from Scotland or Ireland into England, 7s. 10d. per gallon; 6 G. 4, c. 80; 1 W. 4, c. 49; 3 V. c. 17. Made in Scotland for home consumption, or imported from Ireland, 3s. 8d. per gal.; 6 G. 4, c. 58; 1 W. 4, c. 49; 3 V. c. 17. Made in Ireland for home consumption, 2s. 8d. per gal.; 4 & 5 W. 4, c. 75; 3 V. c. 17. Imported from the Channel Islands to England, 9s. per gal.; to Scotland, 4s. 10d. per gal.; to Ireland, 3s. 10d. per gal.; 8 & 9 V. c. 65. Spirits of Ether removed from Scotland to England, 10s. 5d. per gal.; from Ireland to England, 12s. 11d. per gal.; from Ireland to Scotland, 2s. 6d. per gal. Medicated spirits of nitre, &c. removed from Scotland to England, 6s. 3d. per gal.; from Ireland to England, 7s. 9d. per gal.; from Ireland to Scotland, 1s. 6d. per gal. Tinctures, &c. removed from Scotland to England, 4s. 2d. per gal.; from Ireland to England, 5s. 2d. per gal.; from Ireland to Scotland, 1s. per gal. Sweets or made wines removed from Scotland to England, 6d. per gal.; from Ireland to England, 7½d. per gal.; from Ireland to Scotland, 1½d. per gal.; 5 V. sess. 2, c. 25; 6 & 7 V. c. 49.

License to be taken out annually by every Distiller, 10l. 10s.; Rectifier, 10l. 10s.; Dealer, not a retailer, 10l. 10s.; 6 G. 4, c. 81. Dealer, for retailing foreign liqueurs, 2l. 2s.; 11 & 12 V. c. 121. Maker of stills in Scotland or Ireland, 10s. 6d.; 6 G. 4, c. 81. Chemist or other person requiring the use of a still in England, 10s.; 9 & 10 V. c. 90; in Scotland and Ireland, 10s. 6d.; 6 G. 4, c. 81. Retailers of spirits, whose premises are rated under 10l. per annum, 3l. 4s. 1d.; at 10l. and under 20l., 4l. 8s. 2½d.; at 20l. and under 25l., 6l. 12s. 3½d.; at 25l. and under 30l., 7l. 14s. 4d.; at 30l. and under 40l., 8l. 16s. 4½d.; at 40l. and under 50l., 9l. 18s. 5½d.; at 50l. or upwards, 11l. 0s. 6d. Retailers of spirits in Ireland, being licensed to sell coffee, tea, &c., whose premises are rated under 25l. per annum, 9l. 18s. 5½d.; at 25l. and under 30l., 11l. 0s. 6d.; at 30l. and under 40l., 12l. 2s. 6½d.; at 40l. and under 50l., 13l. 4s. 7d.; at 50l. or upwards, 14l. 6s. 7½d.; 6 G. 4, c. 81.

The whole of the preceding license duties include the 5 per cent. additional granted by 3 V. c. 17.

Regulations.—A distiller in England, not established in 1825, must occupy and pay rates for premises in or near a market town, of the annual value of

20l. at least, 6 G. 4, c. 80, ss. 9, 11, and no still can be used of less capacity than 400 gallons, s. 10. And a distillery cannot be carried on upon the same premises with the business of a rectifier, brewer, sweets-maker, vinegar-maker, cider-maker, or refiner of sugar, or communicating therewith, or within a quarter of a mile of a rectifying house, 6 G. 4, c. 80, s. 36; 4 G. 4, c. 94, ss. 131, 132. In Scotland or Ireland, no still can be used of less content than 40 gallons, and no license granted for a still of less content than 500 gallons, without a magistrate's certificate, 4 G. 4, c. 94, ss. 9, 10; and the board may refuse to license small stills, or when there is a rectifier, brewer, &c., in the immediate neighbourhood, s. 13.

After having obtained a license, and before making entry, every distiller is required to erect the following utensils in prescribed form, viz. one wash-charger, one low-wines receiver, one low-wines and feints-charger, one feints-receiver, and one spirit-receiver. He may also erect, in addition, one low-wines receiver, one low-wines and feints-charger, and one feints-receiver; and in England, (in case the distiller shall be desirous of having the discharge cock of his low-wines still unsecured), one spent- lees receiver, 6 G. 4, c. 80, ss. 13—15; 4 G. 4, c. 94, ss. 18—20. Chargers and receivers are required to have dipping-holes made, and dipping-rods inserted, *ib.* In the breast of stills, holes or openings are to be made for the officers to take samples, 6 G. 4, c. 80, s. 17; 4 G. 4, c. 94, s. 24. The end of every worm is to be inclosed in a safe, unless the treasury shall dispense with the use thereof, 6 G. 4, c. 80, s. 18; 4 G. 4, c. 94, s. 26. Proper discharge cocks, pumps, locks, and fastenings, are also to be provided at the expense of the distiller, 6 G. 4, c. 80, ss. 18—22; 4 G. 4, c. 94, s. 28; and proper dipping-places with metal plates made in the fixed vessels, 6 G. 4, c. 80, s. 24; 4 G. 4, c. 94, s. 31; and the position or size of any vessel is not to be altered without notice, 6 G. 4, c. 80, s. 26; 4 G. 4, c. 94, s. 39. The officers may order the water to be drawn off from any worm-tub for examination, 6 G. 4, c. 80, s. 28; 4 G. 4, c. 94, s. 106. And the true content, &c., of casks is to be marked thereon, 6 G. 4, c. 80, s. 29; 4 G. 4, c. 94, s. 32.

Every distiller is required to make entry of his premises and utensils, distinguishing them by particular letters and numbers; and is also to distinguish his pipes by particular colours, 6 G. 4, c. 80, ss. 30—32; 4 G. 4, c. 94, ss. 34, 36. And the officers are thereupon empowered to survey, 6 G. 4, c. 80, ss. 39, 43; 4 G. 4, c. 94, s. 104. A distiller is not allowed to brew or distil on a Sunday, nor to brew and distil at the same time, 6 G. 4, c. 80, ss. 12, 50; 4 G. 4, c. 94, ss. 41, 112.

Every distiller, before he begins to prepare worts, or, having discontinued for a longer period than a month, before he recommences, is required to give *six days'* notice, setting forth the materials he intends to make use of (which must be grain or malt, sugar, potatoes, or mangel-wurzel, *unmixed*); and the particular gravity of the wort he intends to prepare; which gravity in England must not exceed 90 degrees, nor be less than 50; and in Scotland or Ireland, must not exceed 80 degrees, nor be less than 30, 6 G. 4, c. 80, ss. 44, 52; 4 G. 4, c. 94, ss. 44, 47; 2 & 3 W. 4, c. 74. And no wort is to be in any distillery in England, except in the mash-tun, wort-underback, coolers, or coppers, which exceeds the gravity specified in such notice, 6 G. 4, c. 80, s. 52; and no wort is to be in any distillery in Scotland or Ireland, except in the mash-tun or wort-underback, which exceeds the notice gravity by three degrees, 4 G. 4, c. 94, s. 44. But the gravity may be changed at the end of a month on giving *six days'* notice, 6 G. 4, c. 80, s. 52; 4 G. 4, c. 94, s. 44.

Before a distiller commences brewing, he is to give *six hours'* notice; and then or within *six hours* after the brewing, to declare the true quantity and kind of materials used, or to be used, 6 G. 4, c. 80, ss. 51, 52; 4 G. 4, c. 94, ss. 42, 43. The worts of two or more brewings are not allowed to be mixed together, 6 G. 4, c. 80, s. 51; 4 G. 4, c. 94, s. 43. The worts are to be collected

in the fermenting-back within eight hours in England, and six hours in Scotland or Ireland; immediately after which a declaration of the gravity and quantity is to be delivered, and nothing capable of exciting fermentation is to be added for two hours afterwards, unless the officer shall sooner have taken account of the worts, 6 G. 4, c. 80, s. 54; 4 G. 4, c. 94, s. 48. In Scotland and Ireland, the worts are allowed to be cooled in a worts-receiver under certain regulations, 4 G. 4, c. 94, s. 48. If *bad* be used by any distiller, six hours' notice in writing is required before making it, and the quantity is restricted to five gallons for every hundred gallons of wort. The gravity must not exceed the lawful gravity of the wort; and it must be conveyed into the fermenting-back within twenty-four hours after the time specified in the notice, 6 G. 4, c. 80, s. 57; 4 G. 4, c. 94, s. 50.

Before a distiller commences distilling, he is to give a declaration, specifying that the whole of the worts and wash in his distillery are collected in the fermenting-backs; and the officer is required, at any time not less than twelve hours after receiving such declaration, to remove the fastenings of the stills, 6 G. 4, c. 80, ss. 58, 59; 4 G. 4, c. 94, s. 51.

Eight hours' notice is required previously to the removal of wash from the fermenting-back to the wash-charger; and on the officer's attendance and removal of the fastenings, and securing the charging cock of the wash-still, the wash is to be conveyed into the wash-charger, 6 G. 4, c. 80, s. 59; 4 G. 4, c. 94, s. 52. In England, the discharge cock is allowed to be opened only once in *six* hours on a reasonable notice, except where a spent- lees receiver is fixed, when no discharge cock is required, 6 G. 4, c. 80, s. 19; but in Scotland or Ireland, it is left unsecured, except by a valve. The low wines produced from the distillation of the wash contained in each fermenting-back, are required to be collected in the low-wines' receivers, from which they are not allowed to be removed without *four* hours' notice, 6 G. 4, c. 80, ss. 59, 64; 4 G. 4, c. 94, s. 54. The spirits and feints produced from the distillation of low wines, to be collected in receivers, from which, after the officer has taken account of them, they can be removed on *four* hours' notice, 6 G. 4, c. 80, ss. 64, 65; 4 G. 4, c. 94, ss. 54, 55.

Modes of charging Duty.—1. By per centage from wash, according to the attenuation of the gravity, 1 gallon for every 5 degrees attenuated for every 100 gallons wort; or from sugar, 1 gallon for every 4 degrees. 2. From the quantity of proof spirits contained in the low wines; 2 per cent. being allowed for waste in England, and 5 per cent. in Scotland and Ireland. 3. From the quantity of proof spirits contained in the spirits and feints distilled, 6 G. 4, c. 80, ss. 47, 68—69; 4 G. 4, c. 94, ss. 56—59. If the produce of spirits from wash shall exceed the proportions above mentioned as to the gravity of worts, &c., the difference to be charged as "undue excesses," 6 G. 4, c. 80, s. 71; 4 G. 4, c. 94, s. 60. Officer to make a return of the duty charged on the distiller in England, at such times as the Board may direct; and in Scotland or Ireland, within six days after each distilling period, 6 G. 4, c. 80, s. 72; 4 G. 4, c. 94, s. 62. In England, the distiller is to make entry of the wash distilled, the spirits made and the malt used, in each period.

Any officer of the rank of supervisor may distil into low wines all the wash contained in a fermenting-back, or take a sample of wash, not exceeding 20 gallons, and distil it into low wines in a still provided by the Commissioners; and if the proof spirit contained in any such low wines shall exceed the proportion of $1\frac{1}{2}$ gallons per cent. of wash for every 5 degrees of gravity attenuated, the distiller incurs a penalty, 6 G. 4, c. 80, ss. 60—62; 4 G. 4, c. 94, ss. 123—125.

No spirits to be sent out of a distiller's stock, except such as shall be distilled in his distillery, 6 G. 4, c. 80, s. 75; nor of any other strength than 25 or 11 per cent. over proof, or 10 per cent. under proof, nor in any less quantity than 80 gallons in England, or 9 gallons in Scotland or Ireland, except

that spirits of the strength of spirits of wine may be sent from a distillery at or above 43 per cent. over proof in casks containing 20 gallons at least; and no spirits to be sent out without permit, 6 G. 4, c. 80, ss. 81, 115; 4 G. 4, c. 94, s. 120; 11 & 12 V. c. 122, s. 23. Stock account of proof spirits to be kept by the officer: penalty for undue increase or decrease, 6 G. 4, c. 80, s. 79; 4 G. 4, c. 94, s. 64.

A distiller may warehouse spirits without payment of duty either in his own or any general warehouse, situated in that part of the kingdom in which the same were distilled; and spirits may be removed from warehouse to warehouse in the same or any other part of the United Kingdom under such security and regulations as the Board shall direct, and on payment of all duties, 11 & 12 V. c. 122, ss. 1, 2, 3; 4 V. c. 94, ss. 66—71; 6 G. 4, c. 80, ss. 88—92; and 4 & 5 W. 4, c. 75, ss. 4, 5. A distiller may transfer any spirits, warehoused in his own name, in a general warehouse, 11 & 12 V. c. 122, s. 4. Strength at which spirits may be warehoused, and how the same may be removed, 6 G. 4, c. 80, ss. 82, 96; 4 G. 4, c. 94, s. 66; 11 & 12 V. c. 122, s. 19. On delivery of spirits from warehouse in Scotland or Ireland for removal to England, the full English duty is to be paid or secured, 6 G. 4, c. 80, ss. 93, 94. Malt spirits may be removed from Scotland to England for consumption on payment of the English duty, and, in certain cases, without repayment of the malt allowance, 11 & 12 V. c. 122, ss. 8, 9, 12.

Rectifiers are to make entry of their premises and utensils, 6 G. 4, c. 80, s. 30; which are to be open to the inspection of the officers, s. 108; and no person is deemed to be a rectifier who shall not have at least one still of 120 gallons content, exclusive of the head, s. 103. The business of a rectifier cannot be carried on within a quarter of a mile of a distillery, nor upon the same premises or communicating with those of a brewer, sweets, vinegar, cider or perry maker, or sugar refiner, or dealer in or retailer of spirits, ss. 35, 36. A rectifier is not to have in his custody any wash, or other fermented liquor, capable of being distilled into spirits, s. 102; and not to use any still on a Sunday, s. 12; and he is required to provide proper fastenings to his stills, 6 G. 4, c. 80, ss. 22, 104; and the necessary means for enabling the officer to take samples; and to assist him, when necessary, with ladders and lights, s. 42. A rectifier must charge his still with liquor before commencing to work, in the proportion of not less than seven-tenth parts of the content of the still, including the head, and work off the same within sixteen hours, 6 G. 4, c. 80, s. 105. *Twelve* hours' notice of working any still is to be given to the officer, who is to attend and open the furnace-door, and fasten down the head of the still if moveable, or, if fixed, to secure the charging pipe leading thereto, 3 G. 4, c. 52, ss. 73, 74; extended to the United Kingdom and made perpetual by 9 G. 4, c. 45.

On receiving spirits into stock, notice is to be given and the permit delivered to the officer, and bulk is not to be broken until the officer shall have taken account thereof, or within two hours after giving the notice, 6 G. 4, c. 80, s. 111.

Rectifiers not to receive or send out spirits without permit, nor to send out a less quantity at one time, and to one person, than two gallons in bulk; and (in order to preserve a distinction between compounded spirits, foreign and colonial spirits, and plain British spirits) compounded spirits not being spirits of wine, are not allowed to be sent into consumption at a strength exceeding 17 per cent. under proof; 6 G. 4, c. 80, ss. 113, 115; 6 & 7 W. 4, c. 72, s. 14. As the hydrometer will not indicate the strength of sweetened spirits, the rectifier is required to mark the true quantity and strength on the casks containing the same, 6 G. 4, c. 80, s. 112. If, on balancing the stock account any undue increase appears, it is forfeited, and a penalty is incurred; and, if a decrease beyond the quantities sent out by permit and exceeding 5 per cent., a penalty is also incurred; which, however,

in practice, is not sued for, unless such decrease shall be greater than four gallons in any one kind of spirits over the quantity permitted since the stock was last taken, ss. 109, 117.

Every *Dealer* in and *Retailer* of spirits to make entry of his premises and utensils, which are to be distinguished by letters or numbers, and fixed casks to have the contents painted thereon, 11 & 12 V. c. 121, ss. 3, 4. Dealers and retailers to mark the true strength and quantity of compounded spirits on casks, and moveable casks to be branded, ss. 5, 6. A retailer (not a dealer) not to send out spirits to a rectifier, dealer, or retailer. Dealer (not being retailer) not to send out less than 2 gallons at a time, s. 7. Retailer not to be concerned in any distillery, &c. within 2 miles of his premises, and no retail place to have a communication with a distillery, &c., 6 G. 4, c. 80, s. 128. Retailers must be authorised by a magistrate's certificate to keep a public house before they can obtain an Excise license, 6 G. 4, c. 81, s. 14, (and see, as to England, 9 G. 4, c. 61; Scotland, 9 G. 4, c. 58).

Every dealer and retailer to provide a book for entering the particulars of spirits received and sent out, 11 & 12 V. c. 121, s. 12. All spirits sold by dealers to be accompanied by a certificate, and so also by retailers and liqueur dealers when the quantity exceeds one gallon, ss. 13, 14. Penalty for improperly using certificate, s. 15. No dealer or retailer to receive spirits without permit or certificate, and the same to be cancelled on receipt thereof, and afterwards given up to the officer, ss. 16, 17. Bulk not to be broken until one hour after receipt of spirits, s. 19. Stock of any dealer or retailer may be taken by any officer of not less rank than a supervisor; excess to be seized; and any officer may examine and take samples, s. 20. Persons licensed as dealers and rectifiers on the same or adjoining premises to be surveyed as rectifiers, s. 21. No spirits to be purchased except from licensed traders under a penalty of 500*l.*, s. 22. Strength at which British spirits may be kept and sent out of stock, s. 23.

All spirits exceeding one gallon to be removed by permit or certificate, otherwise penalty and forfeiture, s. 24. Persons removing spirits in any quantity exceeding one gallon in any part of the United Kingdom, and refusing to produce a proper permit or certificate, may be arrested and convicted in the penalty of 100*l.*, which is not to be mitigated below 10*l.*; and on non-payment of the penalty to be imprisoned for not more than six, or less than one calendar month, s. 25.

If an officer know or suspect any *private still*, he may obtain a search-warrant; and should any such still be found, the owner or proprietor is liable to a penalty of 200*l.*, 6 G. 4, c. 80, s. 39; and any person found at work may be arrested, 7 & 8 G. 4, c. 53, s. 33 (p. 256). He is also authorised to stop persons removing spirits, and examine the permits, 6 G. 4, c. 80, s. 118. If any person be found *having* spirits he is liable to 100*l.* penalty, and may be detained and conveyed by a peace officer before a justice, who may proceed to immediate conviction, ss. 138—140. No person is knowingly to have in possession spirits which have been removed without payment of duty, s. 133; nor to sell or deliver spirits to be unlawfully retailed, s. 132; and spirits are not to be sold in gaols or workhouses, ss. 134—137. In *Ireland* the officers are empowered, in certain cases, to search for private stills and maltings without warrant; and there are other special provisions for putting down private distillation and malting. See 1 & 2 W. 4, c. 55.

As to grocers in Ireland, see 6 & 7 W. 4, c. 38.

Allowance on spirits made from malt only, and consumed in Scotland, 2 W. 4, c. 29, and made in England or Ireland for exportation, 11 & 12 V. c. 122, s. 13, 8*d.* per gallon; with 5 per cent. additional, 3 V. c. 17; such allowance to be made under certain regulations in the Acts referred to, and 4 G. 4, c. 94; 7 & 8 G. 4, c. 52.

Drawback on English spirits exported from rectifiers' stocks, 7s. 11½*d.* per

gallon; Scotch ditto, 3s. 9½d. per gallon; Irish ditto, 2s. 9½d. per gallon; on malt spirits exported from a warehouse in the United Kingdom, 7½d. per gallon, and 5 per cent. On spirits made from other materials than malt only, 1½d. per gallon; 11 & 12 V. c. 122. On spirit mixtures, medicated spirits, &c., removed from one part of the United Kingdom to another, the same amount as the duties, 5 V. sess. 2, c. 25; 6 & 7 V. c. 49; which drawbacks are to be granted under the regulations contained in the Acts referred to.

Stage Carriages.

Duty for every mile which any stage carriage travels in Great Britain, 1½d., 5 & 6 V. c. 79.

Duty on railways in Great Britain, 5 per cent. on the sums received for the conveyance of passengers, 5 & 6 V. c. 79.

License to be taken out for every stage carriage in Great Britain, 3l. 3s. 0d.; for every supplemental license, 5s., 5 & 6 V. c. 79.

Regulations.—Every person applying for a stage carriage license must be furnished with the form of a requisition, in which certain particulars are to be specified, 2 & 3 W. 4, c. 120, ss. 9, 11. No license to be granted to any person under twenty-one years of age, or in arrear for duties or penalties, s. 8; 5 & 6 V. c. 79, s. 9. On the license being taken out a pair of numbered plates to be given and fixed on the carriage, 2 & 3 W. 4, c. 120, s. 8. The duty on stage carriages to be computed according to the license, except, 1st., where the proprietor obtains the Board's leave to pay on account of the journeys actually performed; 2nd., where he pays a composition duty, ss. 12, 18, 19. Duty not exceeding 50l. recoverable by distress, s. 21; and carriages, horses, &c., liable, into whose hands soever the same may come; and persons disposing of them after notice, accountable for the proceeds, s. 114.

The Acts relating to the duty on railway passengers are 2 & 3 W. 4, c. 120, s. 32; 5 & 6 V. c. 79; and 7 & 8 V. c. 85, s. 9; the last of which exempts government trains.

Sugar.

Duty on sugar made in the United Kingdom, 10s. per cwt., 13 & 14 V. c. 67. As to sugar used in brewing beer, see *Beer*.

Regulations.—Every manufacturer is to make entry of his premises and utensils, 1 V. c. 57, s. 3; which are to be marked and numbered, s. 4; and the Officers of Excise are empowered to enter and survey, s. 5. The utensils are not to be used until gauged, s. 6; nor altered after being gauged, except on notice, s. 7.

Notice is to be given of every grinding or mashing of beet-root to be made into sugar, s. 8; and when the juice or syrup is collected, a declaration of the quantity and gravity is to be given to the officer, who is to attend and take an account of it, s. 9. The officer may take samples, which are to be deemed the gravity of the whole contents of the cistern, s. 10. The juice, after the quantity and gravity have been ascertained, is to be run off to the sugar pan, and kept separate during the process of the manufacture until charged, s. 11. And when the manufacture of sugar is complete, notice is to be given of the time when it will be ready to be weighed, s. 12. There are two modes of charging the duty; first, from the gravity of the syrup, s. 13; secondly, by the weight of the sugar produced, s. 14. And the officer is to make a return of the duty every six weeks, and charge the maker by whatever mode will produce the highest amount of duty, s. 15.

The Commissioners of Excise may prescribe a saccharometer to be used for ascertaining the gravity of the syrup, s. 16. The maker to keep scales and weights, s. 17; and to assist with his servants in weighing, s. 18. Charged

and uncharged sugar to be kept separate, s. 19. Penalty on evading the duty, 500*l.*, s. 20.

Sweets.

License on retailers of sweets in the United Kingdom, 1*l.* 1*s.* 0*d.* per annum, 6 G. 4, c. 81, with 1*s.* 0½*d.* additional, by 3 V. c. 17.

Regulations.—No sweets can be retailed to be consumed on the premises without a magistrate's authority, 6 G. 4, c. 81, s. 14; 4 & 5 W. 4, c. 85, s. 16; and see as to England, 9 G. 4, c. 61; Scotland, 9 G. 4, c. 58.

As to the duty on sweets on removal from Scotland or Ireland, see *Spirits*.

Tea (see *Coffee, &c.*)

Tobacco.

License to be taken out annually by every manufacturer of tobacco or snuff in the United Kingdom, weighing for manufacture in the previous year, not exceeding 20,000*lbs.*, 5*l.* 5*s.*; 20,000*lbs.*, and not exceeding 40,000*lbs.*, 10*l.* 10*s.*; 40,000*lbs.*, and not exceeding 60,000*lbs.*, 15*l.* 15*s.* 0*d.*; 60,000*lbs.*, and not exceeding 80,000*lbs.*, 21*l.*; 80,000*lbs.*, and not exceeding 100,000*lbs.*, 26*l.* 5*s.* 0*d.*; exceeding 100,000*lbs.*, 31*l.* 10*s.* 0*d.* Beginners (and a surcharge on the quantity made), 5*l.* 5*s.* 0*d.* Dealers in tobacco and snuff, 5*s.* 8*d.*, 6 G. 4, c. 81.

The preceding license-duties include the 5 per cent. granted by 3 V. c. 17.

Regulations.—Manufacturers, dealers, and retailers of tobacco and snuff, are to enter their premises, 3 & 4 V. c. 18, s. 2; and officers are empowered to survey, s. 8.

Leaf or unmanufactured tobacco is not to be received into a manufacturer's stock but from the warehouse, and accompanied by a permit, s. 4; which is to be delivered up on the next visit of the officer, s. 5. No leaf or unmanufactured tobacco to be removed without a permit, s. 6.

A book is to be delivered to manufacturers, who are to enter therein all tobacco received, with the name of the person from whom received; which book is to be open to inspection, s. 8; and the license-duty on the manufacturer to be rated on the quantities received in the year previous, s. 9; the book being produced on applying for the license and declaration made of the truth of the entries therein, s. 10.

Manufacturers to use water only in manufacturing tobacco, and no other liquid or substance than as described in manufacturing snuff, 5 & 6 V. c. 93, ss. 1, 2. Penalty on receiving, sending out, or having in possession tobacco or snuff manufactured other than with water, ss. 3, 4. Manufacturers not to have in their possession sugar, honey, leaves, &c., s. 5; but manufacturers who were grocers at the passing of the Act may continue to carry on the trade, s. 6. Officers may take samples, s. 7. No person to cut, colour, or manufacture, or have in his possession any leaves or other matters, to imitate or be mixed with tobacco or snuff. Tobacco-stalks and returns not to be removed in any quantity less than 50*lbs.*, nor without certificate, s. 10. Hawkers may be arrested, s. 13.

No drawback is allowed on cut, roll, or carrot tobacco, containing stalks, 3 & 4 V. c. 18, s. 13; nor on tobacco not properly manufactured, or containing unlawful ingredients, s. 14; and a penalty is incurred on fraudulently attempting to obtain drawback, s. 15.

Vinegar.

License to be taken out by every maker of vinegar or acetic acid, for sale, 5*l.*, 6 G. 4, c. 81; and 5*s.* additional, 3 V. c. 17.

Wine.

License to be taken out annually by every dealer in foreign wine, who shall not have a license for retailing spirits and beer, 10*l.* 10*s.* 0*d.*; ditto, having a license for retailing beer, but not for spirits, 4*l.* 8*s.* 2½*d.*; ditto, having licenses for beer and spirits, 2*l.* 4*s.* 1*d.*, 6 G. 4, c. 81.

The above duties include five per cent. additional, granted by 3 V. c. 17.

Regulations.—Every dealer in and retailer of foreign wine (being also a spirit dealer or retailer) is to make entry of his premises, which are to be open to the inspection of the officers, 5 & 6 W. 4, c. 39, s. 4. No license for selling wine to be consumed on the premises can be granted without a magistrate's authority, 6 G. 4, c. 81; 4 & 5 W. 4, c. 85, s. 16; and see as to England, 9 G. 4, c. 61; and as to Scotland, 9 G. 4, c. 58.

PART III.

FORMS AND INSTRUCTIONS.

Affidavit.

Affidavit to obtain a Search Warrant, 7 & 8 G. 4, c. 53, s. 34.

County } A.B., of S. in the County of Y., Officer of Excise, maketh oath and
of Y. } saith, that he, this Deponent, hath cause to suspect, and that he
to wit. } doth suspect, that a certain quantity of Malt, [or, a certain private
still, or as the case may be], the same being goods and commodities
forfeited under and by virtue of a certain Act of Parliament, relating to the
Revenue of Excise, is deposited or concealed in a certain place, to wit, the
house and premises of C.D. at S. in the County of Y. For that he, this
deponent, hath been informed by one E. F. that he, the said E. F., on the
fifth day of January instant saw a certain quantity of Malt concealed in the said
house and premises. And this deponent further saith, that he believes the
said information to be true. [Or set forth any other cause of suspicion as the
fact may be.]

A. B.

Sworn at S. in the County of Y.

this Sixth day of January 1852

before me.

N. O.

One of Her Majesty's Justices of the Peace for the said County.

Agreement.

Agreement for taking a house.

MEMORANDUM, that it is agreed this sixth day of January, 1852. Between
A. B., of S. in the County of Y., gentleman, on the one part, and C. D., of the
same place, Officer of Excise, on the other part, as follows.

The said A. B. agrees to let to the said C. D., and the said C. D. agrees to
take, from the day of instant, for one year, and [unless either of
the said parties shall give to the other six months' notice to quit, previous to
the end of the said term, but not otherwise] from thence afterwards for
another year, and so from year to year, while and until one of the said parties
shall give to the other six months' notice to quit; all that messuage, or
tenement, situate at S. aforesaid, late in the occupation of L. M., together with
the garden and appurtenances; at and under the yearly rent or sum of £—
sterling, the same to be paid on the day of yearly, during the
term or terms aforesaid, and the first payment to commence on the day
of next; which said rent or sum of £— the said C. D. agrees to pay

command you the said C. D., and E. F., or either of you, that upon the goods and chattels of the said A. B. you should levy the said sum of twenty-five pounds, with all reasonable charges and expences attending the same. And whereas you the said C. D., by a return in writing made under your hand, bearing date this day, have certified to me L. M., Esquire, one of her Majesty's Justices of the Peace for the said county, that you the said C. D., have made diligent search for, but cannot find within the Jurisdiction within which the said warrant was so issued, any goods or chattels of the said A. B., whereon the said sum of twenty-five pounds, charges or expences, or any part thereof, can be levied. Now I, the said last-mentioned Justice, do, in her Majesty's name, authorise, require, and command you the said C. D., and E. F., or either of you, to take and arrest the said A. B., and forthwith to convey him to the gaol of, for, and within the said county, and there to deliver him, with a duplicate of this warrant, to the gaoler of such gaol, there to remain and be kept by such gaoler, until satisfaction shall be made of the said judgment, or until the said A. B. shall be ordered by the Commissioners of Inland Revenue to be liberated or discharged. And all constables and other of her Majesty's Officers are hereby authorised and required to be aiding and assisting to you in the due execution hereof. And you the said gaoler of such gaol are hereby authorised and required to receive and take into your custody the said A. B., there to remain and be kept by you the said gaoler, until satisfaction shall be made of the said judgment, or until the said A. B. shall be ordered by the Commissioners of Inland Revenue to be liberated and discharged. And for you or any or either of you so doing as is before to you respectively directed, this shall be to you or any or either of you respectively a sufficient Warrant and Authority. Given under my hand at S., in the said county, this fifteenth day of February, in the year of our Lord one thousand eight hundred and fifty-two, L. M.

Bonds.

I.—Bond for Payment of a Debt due to the Crown.

KNOW ALL MEN by these presents, that we A. B., of S., in the C. of Y., Maltster, and E. F., and G. H., of the same place, Gentlemen, are held and firmly bound unto our Sovereign Lady VICTORIA, by the Grace of God of the United Kingdom of Great Britain and Ireland Queen, defender of the Faith, in the sum of two hundred pounds of good and lawful money of Great Britain, to be paid to our said Lady the Queen, her heirs or successors; to which payment to be well and truly made we bind ourselves and each of us severally, [and any two or more of us jointly], for and in the whole, our and each and any of our heirs, executors, and administrators, and every of them firmly by these presents. Sealed with our seals. Dated this first day of January, in the year of our Lord one thousand eight hundred and fifty-two.

THE CONDITION of the above-written Bond or Obligation is such, that if the above-bonded A. B., E. F., and G. H., or any or either of them, their or any or either of their heirs, executors, or administrators, do and shall well and truly pay, or cause to be paid, to the Receiver General of Inland Revenue, the sum of one hundred pounds of good and lawful money of Great Britain, on the sixth day of July now next ensuing [or, by the instalments, on the several days and times, and in manner following, that is to say, the sum of twenty pounds, part thereof, on the first day of May now next ensuing, and the further sum of eighty pounds, the residue thereof, on the fifth day of July next ensuing]. Then the above-written bond or obligation to be void, or else to be and remain in full force and virtue.

Signed, sealed, and delivered by the
above-bonded A. B., E. F., and G. H.,
in the presence of C. D. }

A. B. (L. S.)
E. F. (L. S.)
G. H. (L. S.)

II.—*Bond for paying the Value of a Seizure on its Condemnation.*

KNOW ALL MEN, &c. [as above].

WHEREAS on or about the first day of January instant a certain horse and a certain cart [or as the case may be] were seized and detained to the use of her said Majesty for certain cause and causes of forfeiture under the laws concerning her Majesty's Revenue. And whereas the Commissioners of Inland Revenue have, on the application of the above-bounden A. B., ordered the said horse and cart to be delivered up to the said A. B., upon his entering with the above-bounden E. F. and G. H. as his sureties into the above-written bond or obligation with such condition as is hereinafter mentioned. Now the condition of the above-written bond or obligation is such, that if the said horse and cart shall at any time hereafter be lawfully condemned as forfeited, on any account, or for any cause of forfeiture whatsoever, and the above-bounden A. B., E. F., and G. H., or any or either of them, their, or any or either of their heirs, executors, or administrators, do and shall within one calendar month next after such condemnation thereof well and truly pay or cause to be paid into the hands of the said Commissioners of Inland Revenue for the time being, or to such other person or persons as the said Commissioners or any two or more of them shall appoint, the sum of _____ pounds of lawful money of Great Britain; then the above-written bond or obligation to be void, or else to be and remain in full force and virtue.

Signed, &c. [as before].

Commitment.

I.—*Commitment for being found at a private Still or other Manufactory of Excisable Commodities, 7 & 8 G. 4, c. 53, s. 33.*

To Mr. C. D., and to the keeper of the House of Correction at L., in the county of Y.

County } WHEREAS A. B., of L., in the county of Y., is and stands con-
 of Y. } victed this day before me, G. H., Esquire, one of her Majesty's
 to wit. } Justices of the Peace in and for the said county of Y., for that
 one C. D., being an Officer of Excise, did on the first day of January, in the
 year of our Lord one thousand eight hundred and fifty-two, at S., in the
 said county of Y., discover and find in a certain private and unentered
 place manufacturing, and in the course of manufacturing, certain goods and
 commodities for and in respect whereof a duty of excise is imposed, to wit,
 certain British spirits, and certain wort and wash made from molasses [or
 as the case may be], and certain materials and preparations for manufacturing
 such goods and commodities, to wit, certain molasses, and did at the same
 time discover in and about such private and unentered place the said A. B.
 knowingly aiding, assisting, and concerned in the manufacturing of such
 goods and commodities, contrary to the form of the statute in that case made
 and provided, whereby he, the said A. B., hath forfeited and lost the sum of
 thirty pounds: and whereas the said A. B. hath refused and neglected to pay
 the said sum of thirty pounds into the hands of the said C. D., being such
 Officer of Excise as aforesaid, and who conveyed the said A. B. before me in
 pursuance of the said statute, charged with the offence aforesaid. These are
 therefore, to require you the said C. D. to convey the said A. B. to the House
 of Correction at L., in the said county of Y., and to deliver him to the keeper
 thereof, together with this warrant; and I do hereby command you the said
 keeper to receive the said A. B. into your custody in the said House of Correc-
 tion, there to remain, and to be kept to hard labour for the space of three
 calendar months, to be reckoned from the date hereof, or until (during the
 said three months) he shall have paid the said sum of thirty pounds: and for
 so doing this shall be your sufficient warrant. Given under my hand at

S., in the said county of Y., the sixteenth day of January, in the said year of our Lord one thousand eight hundred and fifty-two. G. H.

II.—*Commitment for removing Spirits without Permit or Certificate, 11 & 12 V. c. 121, s. 25.*

To Mr. C. D. and to the keeper of the county gaol at Y., in the county of Y. [or other county prison].

County } WHEREAS on the first day of January now instant, within a certain
of Y. } part of the United Kingdom, to wit, at S., in the county of Y., C. D.,
to wit. } Officer of Excise, stopped and detained A. B., who was then and
there found carrying and removing certain spirits exceeding the quantity of one
gallon of spirits of the same denomination at a time for the same person, that
is to say, two gallons of spirits called whiskey at the same time for the same
person, to wit, a certain person whose name is to me unknown [or as the case
may be], and the said officer having then and there demanded the production of
the permit or certificate accompanying such spirits, did then and there find
that the same were then and there carrying and removing without a true and
lawful permit or certificate accompanying the same, contrary to the form of the
statute in that case made and provided, whereby and by force of the statute in
that case made and provided the said A. B., so offending, incurred the penalty
of one hundred pounds. And the said officer thereupon then and there arrested
and detained the said A. B., and conveyed him before me, G. H., Esquire, one of
her Majesty's Justices of the Peace in and for the said county, and residing
near to the place where the said A. B. was so arrested. And I the said Justice
proceeded as soon afterwards as practicable, that is to say, on the day of the
date hereof, to hear and determine, and did then and there hear and determine
the charge against the said A. B. so arrested as aforesaid; and did there-
upon then and there, on proof upon oath by the said C. D. and E. F., two
credible witnesses, then and there duly sworn and examined in the presence
of the said A. B., convict the said A. B. in such penalty as aforesaid, which
penalty I have mitigated to the sum of twenty pounds. And the said A. B.,
being so convicted as aforesaid, did not forthwith pay down the said penalty
as required and directed by the statute in that behalf. These are therefore in
her Majesty's name to require you the said C. D. to convey the said A. B.
to the said county gaol at L., in the said county, and there deliver him to the
gaoler or keeper thereof, together with this warrant. And you the said
gaoler or keeper of the said county gaol are hereby required to receive the
said A. B. into your custody in the said county gaol, there to remain and be
kept to hard labour for the space of two calendar months, unless the said
penalty of twenty pounds is sooner paid. And for your so doing this shall be
your sufficient warrant. Given, &c. [as above].

Complaint.

Complaint of Overcharge, 4 & 5 W. 4, c. 51, s. 27.

County of } BE it remembered that on the day of , 1852, at , in
 } the county of , J. S. of (being a person chargeable with
and liable to the payment of the duty of excise on), now here in his proper
person exhibits an information and complaint to and before us J. P. and K. P.,
two of her Majesty's Justices of the Peace for the said county of , within
whose jurisdiction the said J. S. hath been charged with and paid such duty
as hereinafter mentioned, and thereby informeth us that within twelve calendar
months last past, that is to say, on the day of , a certain overcharge has
been and was made by , an officer of excise, upon him the said J. S. [or,
a certain overpayment was made by him the said J. S. to an officer of excise]
[or, by a certain act of Parliament relating to the revenue of excise made in
the year, &c., the said J. S. was and is entitled to a return of a certain

duty of excise, to wit, the sum of , paid by the said J. S.]; and that the ground of such overcharge [or, overpayment, or, claim of return or allowance of duty] is that [here insert the particulars of the charge and overcharge, &c., according to the fact]. And thereupon the said J. S. prayeth the judgment of us the said Justices in the premises, and that such order may be made in the premises as by the statute in that case made and provided is required.

Exhibited, &c.

J. S.

Declaration.

Declaration in lieu of Oath, 5 & 6 W. 4, c. 62.

I, A. B., of G , in the county of W , gentleman, do solemnly and sincerely declare that I did, &c. [as the case may be]. And I make this solemn declaration, conscientiously believing the same to be true, and by virtue of the provisions of an act made and passed in the session of Parliament of the fifth and sixth years of the reign of his late Majesty King William the Fourth, intituled, "An Act to repeal an Act of the present session of parliament, intituled, 'An Act for the more effectual abolition of oaths and affirmations taken and made in various departments of the state, and to substitute declarations in lieu thereof, and for the more entire suppression of voluntary and extra-judicial oaths and affidavits; and to make other provisions for the abolition of unnecessary oaths.'"

Declared, &c.

L. M.

Demand.

Demand of Duty in Danger.

To Mr.

The sum of pounds shillings and pence having been charged upon and incurred by you as and for duties of excise on malt [or as the case may be], imposed by the statute in that case made and provided, I, C. D., the Collector of Excise in whose collection [or, Officer of Excise in charge for the time being of the Excise collection in which] [or, an Officer of Excise, authorised and directed in that behalf, by the Collector of Excise in whose collection] the trade and business of a maltster and maker of malt [or as the case may be] was carried on by you at the time such duties were charged upon and incurred by you, do hereby demand of you (under order in that behalf of the Commissioners of Inland Revenue), [and by authority and direction of the said Collector of Excise] [or, Officer of Excise in charge of the said Collection], the payment and clearance off of the said duties so charged upon and incurred by you as aforesaid; and I do hereby, in pursuance of such order, require you forthwith and at the present time to pay the said duties at this place to me, I being duly authorised by the said Commissioners to receive the same; and if you do not forthwith pay and clear off the same according to this demand, you will forfeit and lose double the value of the duties so neglected to be paid and cleared off. Dated at S., in the county of Y., this first day of January, one thousand eight hundred and fifty-two.

C. D.

Entry.

Entry of a Trader's Premises and Utensils, 4 & 5 W. 4, c. 51, s. 5, &c.

I, A. B., of , in parish of , in the county of , do hereby make entry and give notice, as a dealer in [or, manufacturer of] , of the following building [or, place, vessels, and utensils, as the case may be], that is to say, one room marked A, on the ground-floor of my dwelling-house, situate as above, for the purpose of storing and retailing ; [one other room, situate , and marked , for the purpose of ; one store room, No. 1, marked , situate , for the purpose of , one store cask, No. 1, marked , situate , with a pipe, painted colour, connected with

, and running through , as described in the drawing or description hereunto annexed, for the purpose of , &c. or as the case may be]. As witness my hand this day of , 1852, A. B.
Received and signature witnessed by C. D.

Guarantee.

Guarantee of Excise Duty.

I guarantee to you the payment of the duty of Excise charged or to be charged on Mr. A. B., to the amount of £ . Should he fail to pay at the proper time, I bind myself to pay you within seven days from the date of receiving notice from you. A. B.
To C. D., Esq., Collector of Excise, 5th January, 1852.

Information.

I.—Information for Recovery of a Penalty.—General Form, 4 & 5 W. 4, c. 51, s. 19.

County } BE IT REMEMBERED, that on this sixth day of January, in the
of Y. } year of our Lord one thousand eight hundred and fifty-two, at
to wit. } S., in the county of Y., C. D., one of Her Majesty's Officers of
Excise, who prosecutes for her said Majesty in this behalf, exhibiteth, in his
own proper person, to and before me, G. H., one of her Majesty's Justices of
the Peace for the said county, this Information (which same Information is
commenced and prosecuted by order of the Commissioners of Inland Revenue);
and informeth me the said Justice, That [state the offence according to the Act;
see the examples below]. WHEREUPON the said C. D. prayeth judgment in the
premises, and that the said A. B. may be summoned to answer the said
premises, and to make defence thereto.

Exhibited to and before me the day and year, } C. D.
and at the place first above-written, }
G. H.

II.—Information for depositing Goods to evade the Duty, 7 & 8 G. 4, c. 53, s. 32.

BE IT REMEMBERED, &c. [as above], that heretofore and within six calendar months last past, to wit, on the first day of December last past, at S., in the county aforesaid, one A. B. did remove, deposit, and conceal, and was then and there concerned in removing, depositing, and concealing certain goods and commodities, that is to say, twenty gallons of British spirits [or as the case may be], the same spirits then and there being goods and commodities for and in respect whereof a certain duty of Excise was and is by law imposed, with intent to defraud Her Majesty of such duty, contrary to the form of the statute in that case made and provided; whereby and by force of the statute in that case made and provided, the said A. B., so offending as aforesaid, has forfeited and lost the sum of one hundred pounds; the said C. D., who sues for the same, having elected, and hereby electing, the said sum of one hundred pounds, and not treble the value of such goods and commodities; to wit, at S. aforesaid, in the county aforesaid. WHEREUPON, &c. [as above].

III.—Information for fraudulently depositing Malt, 7 & 8 G. 4, c. 52, s. 40.

BE IT REMEMBERED, &c. [as above], that A. B. [being a maltster and maker of malt] did within six calendar months last past, to wit, on the sixth day of December last, to wit, at S., in the county of Y. aforesaid, fraudulently deposit and convey away from the sight of the Officers of Excise ten bushels of malt [and ten bushels of corn and grain then and there making into malt], contrary to the form of the statute in that case made and provided; whereby and by force of the statute in that case made and provided, the said A. B., being the person [or, maltster and maker of malt] so offending as aforesaid, has for such offence forfeited and lost the sum of two hundred pounds. WHEREUPON, &c. [as above].

IV.—*Information for Double Duty due, 4 & 5 W. 4, c. 51, s. 11.*

BE IT REMEMBERED, &c. [as above], that before and at the time of committing the offence hereinafter mentioned, certain duties of Excise imposed by a certain Act of Parliament relating to the revenue of Excise, and amounting to a large sum of money, to wit, the sum of twenty-one pounds, fourteen shillings, had been and were duly charged upon and incurred by one A. B., he the said A. B. being a person carrying on the trade and business of a Maltster [or as the case may be], the same being a trade and business under and subject to certain laws of Excise, in respect of a certain large quantity, to wit, one hundred and sixty bushels of malt, by him made in a certain part of the United Kingdom [or as the case may be], during a certain period of time, (that is to say) between the first day of April now last and the first day of January now instant; and which said duties so charged and incurred as aforesaid had been and were directed by the Commissioners of Inland Revenue to be paid and cleared off by the said A. B. at a certain time within six calendar months last past, to wit, on the sixth day of January now instant, and at a certain place, to wit, at S., in the county aforesaid, and to a certain person, to wit, to one N. O. Yet the said A. B., so being such person as aforesaid, and well knowing the premises aforesaid, did not nor would pay and clear off the said duties so charged upon and incurred by him as aforesaid to the said N. O., at the time and place last aforesaid; but on the contrary thereof, did then and there, to wit, on the day and year last aforesaid, to wit, at S. aforesaid, in the county aforesaid, wholly neglect to pay and clear off the said duties; and the same and every part thereof are still wholly due and unpaid by the said A. B., or by any person on his behalf; contrary to the form of the statute in that case made and provided; whereby and by force of the statute in that case made and provided, he the said A. B., so being such person as aforesaid, hath forfeited and lost double the value of the said duties so by him neglected to be paid and cleared off as aforesaid, amounting to a large sum of money, to wit, the sum of forty-three pounds eight shillings. WHEREUPON, &c. [as above].

V.—*Information for Double Duty after Demand, 4 & 5 W. 4, c. 51, s. 11.*

BE IT REMEMBERED, &c. [as above], that before and at the time of committing the offence hereinafter mentioned, one A. B. was a person carrying on the trade and business of a [maltster], the same being a trade and business under and subject to certain laws of Excise, to wit, at S., in the county aforesaid; And before and at the time of committing such offence, certain duties of Excise imposed by a certain Act of Parliament relating to the revenue of Excise, and amounting to a large sum of money, to wit, the sum of , had been duly charged upon and incurred by the said A. B., as such person as aforesaid, in respect of a certain large quantity, to wit, of [malt], by him made &c. [as above]; And at the time of committing such offence, such duties so charged and incurred as aforesaid had not, nor had any part of the same, been paid and cleared off by the said A. B.; And thereupon afterwards and within six calendar months last past, to wit, on the seventh day of January now instant, at S. aforesaid, in the county aforesaid, one E. F., he the said E. F. then and there being [an Officer of Excise, then and there duly authorised and directed to make such demand as hereinafter mentioned by], the Collector of Excise within whose collection the said A. B. did so carry on his said trade and business as aforesaid, did, under order of the Commissioners of Inland Revenue, make demand upon the said A. B., so being such person as aforesaid, for the payment and clearance off of the said duties so charged upon and incurred by him as aforesaid; and did then and there, in pursuance of such order, require the said A. B. forthwith then and there to pay and clear off such duties to him the said E. F., he the said E. F. then and there being

duly authorised by the said Commissioners to receive the same: Yet the said A. B., so being such person as aforesaid, did not, nor would then and there upon such demand being so made as aforesaid, pay and clear off the said duties as required, according to the terms of the said demand; but on the contrary thereof, did then and there wholly neglect and omit so to do, and the said duties and every part thereof are still wholly due and unpaid by the said A. B., or by any person on his behalf, to wit, at S. aforesaid, in the county aforesaid; contrary, &c. [*as above*]. WHEREUPON, &c. [*as above*].

Levy Warrant.

Levy Warrant for a Penalty, 7 & 8 G. 4, c. 53, s. 86.

To Mr. C. D., and Mr. E. F., Officers of Excise, or either of them.

County } WHEREAS A. B. hath this day been duly convicted by and before us,
of Y. } L. M., and N. O., Esquires, two of her Majesty's Justices of the Peace
to wit. } in and for the county of Y., by the judgment of us, the said Justices,
in the sum of twenty-five pounds, being a [*sum of money to which a certain*]
penalty incurred by the said A. B. for a certain offence heretofore committed
by him in the said County against a certain Act of Parliament relating to the
revenue of Excise [*has been by us mitigated*], and which said sum of twenty-
five pounds was by the said conviction and judgment of us, the said Justices,
recovered against the said A. B., by C. D., Officer of Excise, who prosecuted
by information for her said Majesty in that behalf. Now we, the said
Justices, do, in her Majesty's name, authorise and command you or either of
you, that upon the goods and chattels of the said A. B. you do levy the said sum
of twenty-five pounds with all reasonable charges and expences attending
such levy: and for levying thereof, we do hereby authorise and command
you or either of you to seize and take the goods and chattels aforesaid, and
either to detain and keep the same in the place where the same respectively
shall be found, or to remove the same to the next Office of Excise; and if
within five days next after such seizure, the said sum of twenty-five pounds
shall not be paid or satisfied, then and in such case, as soon as conveniently
may be after the expiration of the said five days, to sell and dispose of the
said goods and chattels, or so much thereof as will be sufficient to levy the
said sum of twenty-five pounds, with all reasonable charges attending such
levy, and to deduct the said last-mentioned sum and the said charges and
expences out of the money arising by such sale, and to return the overplus,
if any, of the said goods and chattels, or of the money arising from the sale
thereof, or of any part thereof, to the proprietor or proprietors of the said
goods and chattels, or the person or persons who shall be legally entitled
thereto; and forthwith to pay the said sum of twenty-five pounds to the
collector of Excise for the time being for the collection called N. Collection,
to be by him applied and answered for according to the statute in such case
made and provided: and all Constables and Headboroughs of the said County
are hereby required to be aiding and assisting to you in the due execution
hereof. Given under our hands, at S., in the said county, this fifth day of
January, in the year of our Lord one thousand eight hundred and fifty-two.

L. M. N. O.

Notice.

I.—Notice for commencing an Operation.

TAKE NOTICE, that I intend to wet grain to be made into malt [*or as the case may be*], on 18 , at o'clock in the morning. Dated at ,
this day of , 18 . A. B.
To Mr. C. D., Officer of Excise. Maltster [*or as the case may be*].

II.—*Notice of Appeal*, 7 & 8 G. 4, c. 53, s. 83.

County } TAKE NOTICE, that I shall appeal and do appeal to the General
 of W. } Quarter Sessions of the Peace, to be holden next after the expiration
 of twenty days from the date hereof, in and for the County of W., from
 the Judgment given this day, by L. M., and N. O., Esquires, being two of
 her Majesty's Justices of the Peace, for the said County of W., in the matter
 of an information exhibited by me on behalf of her Majesty against A. B.,
 for recovery of the Penalty of one hundred pounds [and forfeiture of twenty
 bushels of Malt], for breach of the Excise Laws, and by which Judgment I
 feel myself aggrieved. Dated at S., in the said County of W., this fifth day
 of January, 1852.

To the above-named L. M., and N. O.,
 Justices as aforesaid, and to the above-
 named defendant, A. B., and to the
 Justices of the Peace at the General
 Quarter Sessions above referred to.

C. D.
Officer of Excise.

III.—*Notice to quit a House.*

I hereby give you notice of my intention to quit, and that I shall, on the
 day of next, quit and deliver up the possession of the dwelling-house
 and premises, situate at , which I now occupy as tenant under you [or,
 which you claim that I so hold]. Dated this day of , 18 .

To Mr. C. D.

A. B.

*Petition.*I.—*Petition for Promotion.*

HON. SIRS,
 Having been years in the Service, of which have been in a
 ["Ride," "Division," "District," or as the case may be], I humbly pray
 your Honors will be pleased to order out my books for examination, with a
 view to promotion.

I am, Hon. Sirs,

Your Honors' Dutiful Servant,

8. Jan. 1, 1852.

C. D.

Officer [&c., insert Station, District and Collection].

To the Hon. Commissioners of Inland Revenue,
 Broad Street, London.

II.—*Petition for Removal.*

HON. SIRS,
 I humbly pray your Honors will be pleased to appoint me to the
 first vacancy, which may happen in ["Ride," "Division," "District," or,
 in Collection, or, in any ride, &c. in (or, about) London, or as the
 case may be].

I am, &c. [as above].

III.—*Petition for a Compromise.*

To the Honourable Commissioners of Inland Revenue.

HON. SIRS,
 A prosecution in the Exchequer [or, before the magistrates] has
 been instituted against me, at the suit of your Honourable Board, for the
 penalty [or, forfeiture] of , for [state the offence, with any
 circumstances which it may be considered right to add, in explanation or
 mitigation].

I therefore respectfully request that the sum of £ may be accepted as
 a compromise for this prosecution.

I am, Honourable Sirs,

S.

Your obedient servant,

1st Jan. 1852. }

A. B.

Search Warrant.

Search Warrant under 7 & 8 G. 4, c. 53, s. 34.

County } WHEREAS C. D., Officer of Excise, hath this day made oath
of Y. } before me, one of Her Majesty's Justices of the peace in and for the
to wit. } County of Y., that he hath cause to suspect, and that he doth
suspect, that certain Spirits [*or as the case may be*], the same being goods and
commodities forfeited under and by virtue of a certain Act of Parliament
relating to the Revenue of Excise, are deposited or concealed in a certain
place, to wit, the house and premises of A. B., at S., in the said county of
Y., setting forth, in and by his said oath, the ground of his suspicion;
and the same appearing to me to be reasonable grounds of suspicion; I
therefore, by virtue of the power and authority to me given, do judge it
reasonable, and by this present special warrant, under my hand, do
authorise and empower the said C. D., by day or by night, (but if between
the hours of eleven of the clock at night and five in the morning, then in
the presence of a constable or other lawful officer of the peace,) to enter
into the said place where such goods and commodities are suspected to be
deposited or concealed, and to seize and carry away the same. And all
Constables and other Her Majesty's Officers are hereby authorised and
required to be aiding and assisting to him in the Execution hereof: and for
so doing, this shall be to him and every of them a sufficient Warrant. GIVEN
under my hand, this first day of January, in the year of our Lord one
thousand eight hundred and fifty-two. L. M.

Seizures.

Instructions for making Seizures and Detections.

1. Endeavour to keep your traders honest, and thus avoid the necessity of seizures, if possible.
2. If fraud cannot be prevented without a detection, do it effectually, by a proper arrangement previously made with your superior officer, if practicable.
3. Never attempt to make a seizure or detection single-handed, if it can be avoided. If it cannot, send for your superior or some other officer as soon as possible; and never think of removing a seizure until another witness has been present to corroborate your account of the transaction.
4. On making a seizure lay your hand upon the articles and say, "I seize this whiskey (*or as the case may be*) for the use of Her Majesty." If you happen to be alone when the seizure is made, declare the seizure as soon as any other person is present.
5. Whenever it is practicable, take samples of the seizure upon the premises, and seal them up in the presence of the trader or his servants.
6. If the owner be not present at the seizure, let him be made acquainted with the circumstance as soon afterwards as possible.

Statement.

I.—Instructions for making Statements.

1. State the particulars of the transaction as they occurred, introducing the account when necessary, by any preliminary fact or circumstance that will in the subsequent part of the Report be referred to, so as to make the case plain and easy to be understood.
2. Detail every fact, if more than one, in succession as it arose, one fact after another in priority of time, so as to form one connected detail or chain of relation.
3. If the statement relate to any offence likely to become the subject of

prosecution, state particularly the Christian and Surname of the trader or of each of them, if more than one; his or their residence or place of business and occupation; the time and place, and the full and proper name of the parish and county, shire, division, city, or town, when, where, and within which the transaction occurred.

4. State the penalty or forfeiture which you consider to have been incurred, and the Act and section which you consider to have been violated.

5. Give the trader's own account of the transaction, after seeing him personally, if possible; and state your own opinion of the case and your reasons for admitting or disbelieving the trader's allegations or excuse.

6. State whether the trader has before been guilty of any breach of the Excise Laws, and what are his present circumstances.

7. If a seizure has been made, state the particulars by way of recapitulation in a scheme at the end of your report.

8. Write plainly and distinctly, and make no flourishes either in your composition or penmanship.

II.—*Statement of the Seizure of a private Still.*

Hon. Sirs,

8, January 1, 1852.

On the 26th December, 1851, in consequence of private information, I proceeded in company with Mr. J. S., one of my officers, to a small house, No. 15, in W. Street S., in the Parish of S., in the county of Y., and having with some difficulty obtained admission, we discovered in a back room, on the ground floor, a private still, of the content of 20 gallons, set up in brickwork, charged with molasses wash, and at full work. There were also upon the premises about 150 lbs. of molasses and the usual utensils for carrying on a private distillery upon a considerable scale, the whole of which we seized; and having destroyed the wash, we conveyed the other articles to the Excise Office at S., and delivered the same into the custody of Mr. J. M., the warehouse-keeper there.

On entering the premises we met a man in the passage endeavouring to make his escape, and as he appeared to have been concerned in working the still, we arrested him and conveyed him, on the same day, before G. H., Esq., Justice of the Peace for the County, who immediately entered upon the case, and after examining the witnesses and hearing the prisoner in his defence, convicted him in the penalty of 30*l.*; failing in payment of which he was sentenced to three calendar months' imprisonment, and on the following day was conveyed to X. gaol, where he is now confined.

The prisoner gave his name as A. B., and upon inquiry I find that he took the house in that name of Mr. L. M., the landlord, about three months ago, and I cannot find that any person but himself is the proprietor, although it is probable that he has been assisted with money by some persons whom I am unable at present to discover. I am humbly of opinion that he has incurred the 200*l.* penalty imposed by 6 G. 4, c. 80, s. 39; but he has a large family and seems to be wretchedly poor, and I believe nothing will be recovered from him. There is no doubt that he has been for some time concerned in defrauding the Revenue, but I cannot learn that he has been before detected.

I am, Hon. Sirs,

Your Honors' Dutiful Servt.,

C. D.

Supervisor, S. District, L. Collection.

Add a scheme containing the following particulars in proper columns. 1, Date of seizure; 2, By whom seized; 3, Place of seizure; 4, From whom seized; 5, Articles seized; 6, Packages in which contained; 7, The quantity of each article or species of goods; 8, Value, whether under or over 15*l.*; 9, Act under which seized.

Summons.

I.—*Summons to appear to an Information for a Penalty*, 4 & 5 W. 4, c. 51, s. 19.
 County } YOU ARE HEREBY TO TAKE NOTICE, that an Information
 of Y. } hath this day been laid and exhibited against you before me, G. H.,
 to wit. } one of Her Majesty's Justices of the Peace for the County of Y., by
 C. D., Officer of Excise, in and by which Information it is alleged, that you,
 &c. [State the offence the same as in the Information (see p. 281), using the
 word you, or yours, instead of he, or he the said A. B.] AND YOU WILL
 FURTHER TAKE NOTICE, that the said Information is appointed to be
 heard, adjudged, and determined on Friday the first day of February now
 next, at ten of the clock in the forenoon of the same day, at the Court
 House in S., in the said County, before such of Her Majesty's Justices of the
 Peace for the said County as shall be then and there present, and have Juris-
 diction to hear and determine the same; at which time and place you are to
 appear and plead to and attend the hearing of the said Information to make
 your defence; or otherwise the said Justices will proceed to the hearing and
 determination thereof as if you were present. Dated at S., in the said
 County, this fifth day of January, in the year of our Lord one thousand
 eight hundred and fifty-two. G. H.

To Mr. A. B.

If you have any witnesses who can disprove or extenuate the offence im-
 puted to you, you must bring them with you at the time appointed for trial.

If you bring counsel or attorney, you are requested to give four days'
 notice thereof to the Supervisor of Excise.

II.—*Summons or Subpœna for a Witness to attend a Hearing*, 7 & 8 G. 4, c. 53,
 s. 74.

County } YOU ARE HEREBY REQUIRED by one of Her Majesty's
 of Y. } Justices of the Peace for the County of Y. personally to be and
 to wit. } appear, on Friday the first day of February now next, at ten of
 the clock in the forenoon, at the Court House in S., in the said County,
 before such of Her Majesty's Justices of the Peace having jurisdiction in the
 matter as shall be then and there present, and who will then and there
 hear, adjudge, and determine a certain information there depending, ex-
 hibited under a certain Act of Parliament relating to the Revenue of Excise
 by C. D., Officer of Excise, who prosecutes for her said Majesty in this behalf,
 against A. B., then and there to give evidence upon oath of the truth of any
 facts alleged in such Information, or touching or relating thereto. But if you
 fail therein, you will, by the statute in such case made and provided, forfeit
 fifty pounds. Dated at S. aforesaid, this fifth day of January, in the year
 of our Lord one thousand eight hundred and fifty-two. G. H.

To Mr. Y. Z.

Theme.*Instructions for writing a Theme.*

1. Observe, that in requiring a Supervisor to write a Theme, it is not
 expected that he should do it in the logical form used at the universities;
 the object being simply to test his powers of composition, and his practical
 knowledge of the subject on which he is required to write.

2. Before beginning to write, reflect well on the nature and bearings of the
 proposition submitted to you, and the mode in which it ought to be treated,
 and fix upon some general arrangement.

3. Consider the subject as a question referred by the Board for you to
 report upon; and proceed to answer it accordingly in a plain and perspicuous
 manner, adopting the same kind of language as you use in making your
 statements to the Board, without any attempt at rhetorical embellishment.

4. Should the proposition involve any point of revenue law or practice, take a comprehensive view of the regulations upon the subject as they at present exist, and point out any defects which may have occurred to you therein, and the remedy which you consider ought to be adopted for their correction. Especially advert to any matter, the adoption of which would, in your judgment, be likely to benefit the revenue.

5. Confine your attention to the proposition under consideration, without allowing yourself to digress from it by irrelevant or collateral matter, however otherwise important; and endeavour to complete one part of your subject before you enter upon another.

6. In conclusion, it may be as well to refer to and answer any objections which you think are likely to be raised against your views upon the whole subject, or any particular point which you may have urged.

FORM III.

Will devising Property to Wife absolutely.

THIS IS THE LAST WILL AND TESTAMENT of me, A. B., of L., in the county of M., Officer of Excise, made this day of , one thousand eight hundred and fifty-two, as follows:—I give, devise, and bequeath all my messuages, lands, tenements, and hereditaments, and all my household furniture, ready money, securities for money, money secured by life assurance, goods and chattels, and all other my real and personal estate and effects whatsoever and wheresoever, unto my dear wife, C. B., her heirs, executors, administrators, and assigns, to and for her and their own absolute use and benefit, according to the nature and quality thereof respectively, subject only to the payment of my just debts, funeral and testamentary expences. And I appoint my said wife executrix of this my will, and hereby revoke all other wills. In witness whereof, I have hereunto set my hand and seal, the day and year above written. A. B. (L. s.)

Signed, sealed, published, and acknowledged by the said A. B., as and for his last will and testament, in the presence of us, who, in his presence, and at his request, and in the presence of each other, have subscribed our names as witnesses.

C. D., E. F., G. H.

FORM IV.

Withdrawal of an Entry.

Take notice, that I, A. B., of S., &c., do hereby withdraw all and every entry and entries of rooms, places, and utensils, made by me as a at S. aforesaid, I having wholly discontinued the said trade and business. Dated this day of , 185 .

To Mr. C. D., Officer of Excise, and }
all others whom it may concern. }

A. B.

PART IV.

MISCELLANEOUS TABLES.

No. 1.

TABLE OF STERLING MONEY.

Farthings.	Pence.	Shillings.	Pounds.
4	1	1	1
48	12	20	
960	240		

£ signifies pounds or sovereigns; s., shillings; d., pence; a half-sovereign is 10s.; a crown, 5s.; a half-crown, 2s. 6d.; a sixpenny piece, 6d.; a fourpenny piece, 4d.; a halfpenny, $\frac{1}{2}$ d.; a farthing, $\frac{1}{4}$ d. A sovereign that weighs 5 *dwt.* 2 $\frac{1}{4}$ *gr.*, is a legal tender; its full weight is 5 *dwt.* 3 $\frac{1}{4}$ *gr.* 1 lb. (troy) of gold is coined into 46 $\frac{2}{3}$ sovereigns; 1 lb. (troy) of silver into 66 shillings; 1 lb. (avoirdupois) of copper into 24 pence. Gold coin is a legal tender to any amount; silver coin to the amount of 40s.; copper coin to the amount of 12d. The usual value of gold is nearly £4 an ounce, or 2d. a grain; and that of silver 5s. an ounce. The value of a French franc is about 9 $\frac{1}{2}$ d. sterling, and that of the American dollar about 4s. 1d. sterling.

No. 2.

DECIMAL AND FRACTIONAL PARTS OF A POUND STERLING.

Pence.	Decimals.	Pence.	Decimals.	Pence.	Decimals.	Pence.	Decimals.	Pence.	Decimals.	Pence.	Decimals.
1	001042	2	009375	3	017708	4	026043	5	034375	6	042708
1	002083	2	010417	3	01875	4	027083	5	035417	6	04375
1	003125	2	011458	3	019792	4	028125	5	036458	6	044792
1	004166	3	0125	5	020833	7	029166	9	0375	11	045833
1	005208	3	013542	5	021875	7	030208	9	038542	11	046875
1	006250	3	014583	5	022917	7	03125	9	039583	11	047917
1	007291	3	015625	5	023958	7	032292	9	040625	11	048958
1	008333	4	016666	6	025	8	033333	10	041666		

s. d.	Frac.	Dec.	s. d.	Frac.	Dec.	s. d.	Frac.	Dec.	s. d.	Frac.	Dec.	s. d.	Frac.	Dec.
1	0	1	0	1	05	3	4	167	6	8	333	9	0	450
2	0	1	4	0	1	7	0	350	10	0	5	13	4	667
2	6	125	5	0	250	7	6	375	11	0	550	14	0	7
3	0	150	6	0	3	8	0	4	12	0	6	15	0	75

No. 3.

TIME.

Seconds.	Minutes.	Hours.	Days.	Weeks.	Months.	Year
60	1					
3600	60	1				
86400	1440	24	1			
604800	10080	168	7	1		
2419200	40320	672	28	4	1	
31557600	525960	8766	365½	52	13 Lunar or 12 Cal.	1

A common year is 365 days; a leap year (once in every fourth year) is 366 days. The precise length of the year is 365 days, 5 hours, 48 minutes, 49·19 seconds. The usual quarter-days are Lady-day, 25th March; Midsommer, 24th June; Michaelmas, 29th September, and Christmas, 25th December. In Excise matters the quarters end according to the old style, viz.: 5th April, 5th July, 10th October, and 5th January. The length of the different calendar months may be remembered from these couplets:—

Thirty days hath September,
April, June, and November,
And all the rest have thirty-one,

But February; that alone
Hath always twenty-eight days clear;
And twenty-nine in each Leap-year.

No. 4.

TABLE FOR FINDING THE NUMBER OF DAYS BETWEEN ONE MONTH AND ANOTHER.

	FROM											
	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
January..	0	334	306	275	245	214	184	153	122	92	61	31
February	31	0	337	306	276	245	215	184	153	123	92	62
March ..	59	28	0	334	304	273	243	212	181	151	120	90
April	90	59	31	0	335	304	274	243	212	182	151	121
May	120	89	61	30	0	334	304	273	242	212	181	151
June	151	120	92	61	31	0	335	304	273	243	212	182
TO July	181	150	122	91	61	30	0	334	303	273	242	212
August ..	212	181	153	122	92	61	31	0	334	304	273	243
Septembr.	243	212	184	153	123	92	62	31	0	335	304	274
October ..	273	242	214	183	153	123	93	61	30	0	334	304
November	304	273	245	214	184	153	123	92	61	31	0	335
December	334	303	275	244	214	183	153	122	91	61	30	0

No. 5.

AVOIRDUPOIS WEIGHT.

Grains.	Drams.	Ounces.	Pounds.	Gallons.	Stones.	Qrs.	Cwt.	Ton
27 $\frac{1}{4}$	1							
437 $\frac{1}{2}$	16	1						
7000	256	16	1					
70000	2560	160	10	1				
98000	3584	224	14	1 $\frac{1}{2}$	1			
196000	7168	448	28	2 $\frac{1}{2}$	2	1		
784000	28672	1792	112	11 $\frac{1}{2}$	8	4	1	
15680000	573440	35840	2240	69 $\frac{1}{2}$	160	80	20	1

No. 6.

FRACTIONS AND DECIMAL PARTS OF A POUND AVOIRDUPOIS.

Ounces.	Solid Inches.	Frac.	Decim.	Ounces.	Solid Inches.	Frac.	Decim.	Ounces.	Solid Inches.	Frac.	Decim.
$\frac{1}{2}$	.433	$\frac{1}{2}$	.016	3	5.199	$\frac{3}{4}$	.1875	9	15.597	$\frac{9}{16}$	.5625
$\frac{1}{4}$	.866	$\frac{1}{4}$	.031	$\frac{3}{2}$	5.545	$\frac{1}{2}$	.2	10	17.330	$\frac{1}{2}$	.625
$\frac{1}{8}$	1.733	$\frac{1}{8}$	.0625	4	6.932	$\frac{1}{4}$	.25	11	19.063	$\frac{1}{4}$	.6875
$\frac{1}{16}$	3.310	$\frac{1}{16}$	.083	5	8.665	$\frac{1}{8}$	.3125	12	20.726	$\frac{3}{8}$	.75
$\frac{1}{32}$	6.773	$\frac{1}{32}$	.1	6	10.398	$\frac{1}{16}$	.375	13	22.528	$\frac{1}{8}$	.8125
$\frac{1}{64}$	13.466	$\frac{1}{64}$	.125	7	12.131	$\frac{1}{32}$	.4375	14	24.261	$\frac{1}{16}$	.875
$\frac{1}{128}$	26.931	$\frac{1}{128}$	.167	8	13.864	$\frac{1}{64}$	.5	15	25.994	$\frac{1}{32}$	.9375

No. 7.

TABLE OF PRICES PER HUNDRED WEIGHT AND PER POUND, AVOIRDUPOIS.

lb. cwt.				lb. cwt.				lb. cwt.				lb. cwt.				lb. cwt.						
d.	£	s.	d.	d.	£	s.	d.	d.	£	s.	d.	d.	£	s.	d.	d.	£	s.	d.			
0	0	2	4	24	1	3	4	48	2	4	4	4	4	13	4	1	7	8	17	4		
0	0	4	8	28	1	5	8	5	2	6	8	0	11	5	9	8	1	8	9	6	8	
0	0	7	0	3	1	8	0	54	2	9	0	0	1	0	5	12	1	9	9	16	0	
0	0	9	4	34	1	10	4	54	2	11	4	1	1	16	1	4	1	10	5	4	4	
0	0	11	8	34	1	12	8	54	2	13	8	1	1	18	10	8	1	11	10	14	8	
0	0	14	0	34	1	15	0	6	2	16	0	0	3	7	0	10	9	0	11	4	0	
0	0	16	4	4	1	17	4	7	3	5	4	1	1	4	17	8	4	3	0	16	0	
0	0	18	8	44	1	19	8	8	3	14	8	1	1	5	7	18	9	4	0	23	8	0
1	1	1	0	44	2	2	0	9	4	4	0	1	1	6	8	8	0	5	0	28	0	0

No. 8.

MEASURE OF CAPACITY, FOR ALE, BEER, &c.

lbs. wt. of distilled Water.	Cubic Inches.	Pints.	Quarts.	Gallons.	Firkins.	Kilder- kins.	Barrels.	Hog- heads.	Fun- cheons.	Butts.	Tun.
1	34.659	1									
2	69.318	2									
10	377.274	8									
90	3495.466	72	36	9							
180	4990.932	144	72	18	1						
260	9981.864	288	144	36	2	1					
540	14972.796	432	216	54	4	2	1				
720	19963.728	576	288	72	6	3	1	1			
1080	29945.592	864	432	108	9	4	2	1	1		
2160	59891.184	1728	864	216	18	8	4	2	2	1	1

No. 9.

MEASURE OF CAPACITY, FOR WINE, SPIRITS, &c.

lbs. wt. of distilled Water.	Cubic Inches.	Gills.	Pints.	Quarts.	Gallons.	Ankers.	Runlets.	Barrels.	Tierces.	Hogs- heads.	Punchon	Pipes or Butts.	Tun.
1	8.664	1											
2	17.328	2											
10	86.64	10											
100	866.4	100											
180	1559.52	180											
315	2734.131	315											
420	3655.68	420											
630	5468.52	630											
840	7321.016	840											
1260	10936.524	1260											
2520	21873.048	2520											

No. 10.

FRACTIONS AND DECIMAL PARTS OF A GALLON.

Pints.	Solid Inches.	Fracts.	Decms.	Pints.	Solid Inches.	Fracts.	Decms.	Pints.	Solid Inches.	Fracts.	Decms.
1	8.664	$\frac{1}{2}$	.031	1	46.213	$\frac{1}{2}$	.167	4	138.637	$\frac{1}{2}$	.500
2	17.328	$\frac{1}{4}$	.0625	2	55.455	$\frac{1}{4}$	.200	5	173.296	$\frac{1}{4}$	.625
3	25.992	$\frac{3}{4}$	.1	3	69.318	$\frac{3}{4}$	.250	6	207.955	$\frac{3}{4}$	.75
4	34.656	1	.125	4	103.978	1	.375	7	242.615	1	.875

No. 11.

MEASURE OF CAPACITY, FOR CORN AND DRY GOODS.

lbs. wt. of distilled Water.	Cubic Inches.	Pints.	Quarts.	Pottles.	Gallons.	Pecks.	Bushels.	Strikes.	Coombs.	Quarters.	Ways or Loads.	Last.
1 $\frac{1}{2}$	34-659 $\frac{1}{2}$	1										
2 $\frac{1}{2}$	69-318 $\frac{1}{2}$	2										
5	138-637	4										
10	277-274	8										
20	554-548	16										
40	1108-1096	32										
80	2218-1992	64										
160	4436-3884	128										
320	8872-7668	256										
640	17745-5386	512										
3200	88727-680	2560										
6400	177455-360	5120										

No. 12.

FRACTIONAL AND DECIMAL PARTS OF A BUSHEL.

Measure.	Solid Inches.	Fractions.	Decimals.	Measure.	Solid Inches.	Fractions.	Decimals.	Measure.	Solid Inches.	Fractions.	Decimals.
1 pt.	34-659	$\frac{1}{4}$	.016	1 $\frac{1}{2}$ gal.	369-699	$\frac{1}{2}$	.167	18 qts.	1247-733	$\frac{1}{2}$	.5625
1 qt.	69-318	$\frac{1}{2}$	.031	1 gal.	443-638	$\frac{1}{2}$	.2	5 gal.	1386-37	$\frac{1}{2}$	.625
2 qts.	138-637	$\frac{1}{2}$	.0625	2 gal.	554-548	$\frac{1}{2}$	.25	22 qts.	1535-007	$\frac{1}{2}$	.6875
2 $\frac{1}{2}$ qt.	184-849	$\frac{1}{2}$	.083	10 qts.	698-185	$\frac{1}{2}$	.3125	6 gal.	1663-644	$\frac{1}{2}$	.75
3 $\frac{1}{2}$ qt.	231-8192	$\frac{1}{2}$	.1	3 gal.	831-822	$\frac{1}{2}$	.375	26 qts.	1802-281	$\frac{1}{2}$	.8125
1 gal.	277-274	$\frac{1}{2}$	.125	14 qts.	970-459	$\frac{1}{2}$	.4375	7 gal.	1940-918	$\frac{1}{2}$	.875
6 qts.	415-911	$\frac{1}{2}$	.1875	4 gal.	1109-096	$\frac{1}{2}$	.5	30 qts.	2079-555	$\frac{1}{2}$	.9375

No. 13.

DIMENSIONS OF THE IMPERIAL MEASURES OF CAPACITY IN INCHES AND DECIMALS
AND ALSO IN INCHES AND THE NEAREST FRACTIONS.

Imperial Dry Measure.	Depths.	Inside Diameter.	Outside Diameter at Mouth.	Breadth at the Edge.	Height of the Heap.
	Inches.	Inches.	Inches.	Inches.	Inches.
Bushel	8-0000 8	18-7892 18 $\frac{1}{8}$	19-5000 19 $\frac{1}{2}$	.3553 $\frac{1}{8}$	6-0000 6
Half-bushel	6-3496 6 $\frac{1}{8}$	14-9130 14 $\frac{1}{8}$	15-4771 15 $\frac{1}{2}$	.2820 $\frac{1}{8}$	4-7622 4 $\frac{1}{2}$
Peck	5-0396 5 $\frac{1}{8}$	11-8364 11 $\frac{1}{8}$	12-2842 12 $\frac{1}{8}$	.2239 $\frac{1}{8}$	3-7797 3 $\frac{1}{2}$
Gallon	4-0000 4	9-3946 9 $\frac{1}{8}$	9-7500 9 $\frac{1}{2}$	.1776 $\frac{1}{8}$	3-0000 3
Half-gallon	3-1748 3 $\frac{1}{8}$	7-4565 7 $\frac{1}{8}$	7-7385 7 $\frac{1}{2}$	.1410 $\frac{1}{8}$	2-3811 2 $\frac{1}{2}$
Quart	2-5198 2 $\frac{1}{2}$	5-9182 5 $\frac{1}{8}$	6-1421 6 $\frac{1}{8}$	.1119 $\frac{1}{8}$	1-8698 1 $\frac{1}{2}$

No. 14.

LINEAL MEASURE.

Inches.	Gunter's Links.	Feet.	Yards.	Fathoms.	Rods, Poles, or Perches.	Gunter's Chains.	Furlongs.	Mile.
$7\frac{1}{2}$	1							
12	$1\frac{1}{2}$							
36	$4\frac{1}{2}$	1						
72	9	2						
192	25	$16\frac{1}{2}$	5	$2\frac{1}{2}$	1			
792	100	66	22	11	4	1		
7920	1000	660	220	110	40	10	1	
63360	8000	5280	1760	880	320	80	8	1

No. 15.

SQUARE MEASURE.

Square Inches.	Square Links.	Square Feet.	Square Yards.	Sq. Rods, Perches, or Poles.	Square Chains.	Square Roods.	Square Acres.	Sq. Mile.
$69\frac{1}{4}$	1							
144	$2\frac{1}{4}$	1						
1296	$20\frac{1}{4}$	9						
39204	625	$272\frac{1}{4}$	$30\frac{1}{4}$	1				
637264	10000	4356	484	$16\frac{1}{4}$	1			
1568160	25000	10890	1210	40	$2\frac{1}{4}$	1		
6272640	100000	43560	4840	160	10	4	1	
4014489600	64000000	27878400	3097600	102400	6400	2560	640	1

No. 16.

SOLID MEASURE.

Cubic Inches.	Cubic Feet.	Cubic Yards.
1728	1	
46656	27	1

1000 ounces of distilled water = 1 cubic foot, and 1 lb. = 27·7274 inches.

No. 17.

ANGULAR MEASURE, OR THE DIVISIONS OF A CIRCLE.

60 Seconds = 1 Minute'	90 Degrees = 1 Quadrant (qdt.)
60 Minutes = 1 Degree°	4 Quadrants = 1 Circle O

No. 18.

MISCELLANEOUS WEIGHTS AND MEASURES.

<i>Apothecaries' Weight.</i>	
20 grains	make 1 scruple.
3 scruples	 1 dram.
8 drams	 1 ounce.
<i>Bread.</i>	
2 pounds	 4-quarter loaf.
4 pounds	 1 quarter loaf.
<i>Bricks.</i>	
500	 1 load.
<i>Candles.</i>	
120 pounds	 1 barrel.
<i>Cheese and Butter.</i>	
8 pounds	 1 nail.
32 cloves	 1 wey (Essex).
42 cloves	 1 wey (Suffolk).
56 pounds	 1 firkin.
224 pounds	 1 barrel.
<i>Cloth.</i>	
24 inches	 1 nail.
4 nails	 1 quarter.
3 quarters	 1 Flemish ell.
4 quarters	 1 yard.
5 quarters	 1 English ell.
6 quarters	 1 French ell.
<i>Coals.</i>	
88 pounds	 1 bushel.
3168 pounds	 1 chaldron.
224 pounds	 1 sack.
10 sacks	 1 ton.
<i>Corn.</i>	
5 bushels	 1 load.
40 bushels	 1 cart.
60 pounds	 1 bush. of wheat
52 pounds	 1 bush. of rye.
47 pounds	 1 bush. of barley
88 pounds	 1 bush. of oats.
<i>Flour.</i>	
14 pounds	 1 peck.
56 pounds	 1 bushel.
280 pounds	 1 sack.
5 bushels	 1 sack.
<i>Glass.</i>	
120 pounds	 1 seam.
<i>Hay (new).</i>	
60 pounds	 1 truss.
<i>Hay (old).</i>	
56 pounds	 1 truss.
36 trusses	 1 load.
<i>Hops.</i>	
112 pounds	 1 packet (Surrey and Sussex).
250 pounds	 1 bag (Kent).
<i>Meal.</i>	
8 pounds	 1 stone.
<i>Oatmeal.</i>	
200 pounds	 1 barrel.
<i>Oil (train).</i>	
9 pounds 6 ounces	 1 gallon.
<i>Oil (sweet).</i>	
226 pounds	make 1 tun.
<i>Paper.</i>	
20 sheets	 1 quire, outside.
24 sheets	 1 quire, inside.
20 quires	 1 ream.
214 quires	 1 printer's ream
2 reams	 1 bundle.
10 reams	 1 bale.
<i>Parchment.</i>	
60 skins	 1 roll.
<i>Potatoes.</i>	
200 pounds	 1 barrel.
<i>Raisins.</i>	
112 pounds	 1 barrel.
<i>Rice.</i>	
168 pounds	 1 barrel.
<i>Salt.</i>	
14 pounds	 1 peck.
56 pounds	 1 bushel.
42 bushels	 1 ton.
<i>Soap.</i>	
64 pounds, or	8 gallons .. 1 firkin.
256 pounds	 1 barrel.
<i>Straw.</i>	
36 pounds	 1 truss.
<i>Tea.</i>	
48 lbs. (about)	 1 chest.
<i>Tyres.</i>	
1000	 1 load.
<i>Tobacco.</i>	
2 to 3 cwt.	 1 barrel.
<i>Water.</i>	
1000 ounces	 1 cubic foot.
<i>Wine.</i>	
138 gallons	 1 pipe of Port.
140 gallons	 1 do. of Lisbon.
110 gallons	 1 do. of Madeira.
120 gallons	 1 do. Tenerife.
57 gallons	 1 hhd. of Claret.
36 gallons	 1 aum. of Hock.
20 gallons	 1 hhd. of Sherry.
130 gallons	 1 butt of Sherry.
<i>Wood.</i>	
1000 billets	 1 cord.
10 cwt.	 1 cord.
108 feet	 1 stack.
128 feet	 1 cord.
<i>Wool.</i>	
7 pounds	 1 clove.
2 cloves	 1 stone.
2 stones	 1 tod.
64 tods	 1 Wey.
2 weys	 1 sack.
12 sacks, or	4368 pounds
240 pounds	 1 last.
	 1 pack.

No. 19.

SPECIFIC GRAVITIES.

Acid, sulphuric	1·840	Gold, hammered	19·362
" nitric	1·270	" sovereign	18·769
" muriatic	1·194	" trinket	17·647
Air, atmospheric	·00303	Iron, cast	7·307
Alcohol, absolute	·793	Naphtha	·708 to ·857
" $\frac{1}{2}$ water } at 51°	·923	Mercury 60°	13·580
" (proof) } at 60°	·920	Platinum	19·500
" $\frac{1}{2}$ water, at 60°	·832	" compressed	22·069
" " "	·863	Silver, virgin	10·474
" " "	·889	" hammered	10·511
" " "	·912	" shilling	10·534
" " "	·933	Soap, hard, hot	·990
" " "	·951	" " cold	1·0216
" " "	·964	" " legal maximum	1·05
" " "	·975	" silicated, hot	1·1533
" " "	·985	" " cold	1·1900
" spirits of wine 48 o.p.	·860	" soft	1·0884
" brandy ·920 (proof) to ·965		" Castile	1·0705
Beer, pale	1·023	Vinegar	1·010
" brown	1·034	" distilled	1·025
Brass, cast	8·395	Water 60° (distilled)	1·000
Copper, (ore soft)	8·572	" more correctly	·9992
" cast	7·788 to 8·900	" 50°	1·0007
Ether	·775	" 35° (maximum gr.)	1·0009
Gas, oxygen	·00132	" 212°	·9562
" hydrogen	·00008	Wine, port	·997
Gold, pure	19·258	" sherry	·992

SPIRITS ACCORDING TO THE INDICATIONS ON SIKE'S HYDROMETER.

Ind.	Sp.Gr.	Ind.	Sp.Gr.	Ind.	Sp.Gr.	Ind.	Sp.Gr.	Ind.	Sp.Gr.	Ind.	Sp.Gr.
0	·8156	5	·8245	10	·8333	15	·8420	20	·8506	25	·8590
2	·8160	2	·8249	2	·8336	2	·8424	2	·8510	2	·8594
4	·8163	4	·8252	4	·8340	4	·8427	4	·8513	4	·8597
6	·8167	6	·8256	6	·8344	6	·8431	6	·8516	6	·8601
8	·8170	8	·8259	8	·8347	8	·8434	8	·8520	8	·8604
1	·8174	6	·8263	11	·8351	16	·8438	21	·8523	26	·8608
2	·8178	2	·8266	2	·8354	2	·8441	2	·8527	2	·8611
4	·8181	4	·8270	4	·8358	4	·8445	4	·8530	4	·8615
6	·8185	6	·8273	6	·8362	6	·8448	6	·8533	6	·8618
8	·8188	8	·8277	8	·8365	8	·8452	8	·8537	8	·8622
2	·8192	7	·8280	12	·8369	17	·8455	22	·8540	27	·8625
2	·8196	2	·8284	2	·8372	2	·8459	2	·8543	2	·8629
4	·8199	4	·8287	4	·8376	4	·8462	4	·8547	4	·8632
6	·8203	6	·8291	6	·8379	6	·8465	6	·8550	6	·8636
8	·8206	8	·8294	8	·8383	8	·8469	8	·8553	8	·8639
3	·8210	8	·8296	13	·8386	18	·8472	23	·8556	28	·8643
2	·8214	2	·8301	2	·8390	2	·8476	2	·8560	2	·8646
4	·8218	4	·8305	4	·8393	4	·8480	4	·8563	4	·8650
6	·8221	6	·8308	6	·8396	6	·8482	6	·8566	6	·8653
8	·8224	8	·8312	8	·8400	8	·8486	8	·8570	8	·8657
4	·8227	9	·8315	14	·8403	19	·8490	24	·8573	29	·8660
2	·8231	2	·8319	2	·8407	2	·8493	2	·8577	2	·8664
4	·8234	4	·8322	4	·8410	4	·8496	4	·8580	4	·8667
6	·8238	6	·8326	6	·8413	6	·8499	6	·8583	6	·8671
8	·8242	8	·8329	8	·8417	8	·8503	8	·8587	8	·8674

SPECIFIC GRAVITIES—continued.

SPIRITS ACCORDING TO THE INDICATIONS ON SIKES'S HYDROMETER—continued.

Ind.	Sp.Gr.	Ind.	Sp.Gr.	Ind.	Sp.Gr.	Ind.	Sp.Gr.	Ind.	Sp.Gr.	Ind.	Sp.Gr.
30-	.8678	42-	.8890	54-	.9111	66-	.9337	78-	.9569	90-	.9806
-2	.8681	-2	.8894	-2	.9115	-2	.9341	-2	.9573	-2	.9810
-4	.8685	-4	.8897	-4	.9118	-4	.9345	-4	.9577	-4	.9814
-6	.8688	-6	.8901	-6	.9122	-6	.9349	-6	.9580	-6	.9818
-8	.8692	-8	.8904	-8	.9126	-8	.9353	-8	.9584	-8	.9822
31-	.8695	43-	.8908	55-	.9130	67-	.9357	79-	.9588	91-	.9826
-2	.8699	-2	.8912	-2	.9134	-2	.9360	-2	.9592	-2	.9830
-4	.8702	-4	.8915	-4	.9137	-4	.9364	-4	.9596	-4	.9834
-6	.8706	-6	.8919	-6	.9141	-6	.9368	-6	.9599	-6	.9838
-8	.8709	-8	.8922	-8	.9145	-8	.9372	-8	.9603	-8	.9842
32-	.8713	44-	.8926	56-	.9148	68-	.9376	80-	.9607	92-	.9846
-2	.8716	-2	.8930	-2	.9152	-2	.9380	-2	.9611	-2	.9850
-4	.8720	-4	.8933	-4	.9156	-4	.9384	-4	.9615	-4	.9854
-6	.8723	-6	.8937	-6	.9159	-6	.9388	-6	.9619	-6	.9858
-8	.8727	-8	.8940	-8	.9163	-8	.9392	-8	.9623	-8	.9862
33-	.8730	45-	.8944	57-	.9167	69-	.9396	81-	.9627	93-	.9866
-2	.8734	-2	.8948	-2	.9170	-2	.9399	-2	.9631	-2	.9870
-4	.8737	-4	.8951	-4	.9174	-4	.9403	-4	.9635	-4	.9874
-6	.8741	-6	.8955	-6	.9178	-6	.9407	-6	.9639	-6	.9878
-8	.8744	-8	.8959	-8	.9182	-8	.9411	-8	.9643	-8	.9882
34-	.8748	46-	.8963	58-	.9185	70-	.9415	82-	.9646	94-	.9886
-2	.8751	-2	.8966	-2	.9189	-2	.9419	-2	.9650	-2	.9890
-4	.8755	-4	.8970	-4	.9192	-4	.9422	-4	.9654	-4	.9894
-6	.8758	-6	.8974	-6	.9196	-6	.9426	-6	.9657	-6	.9898
-8	.8762	-8	.8977	-8	.9200	-8	.9430	-8	.9661	-8	.9902
35-	.8765	47-	.8981	59-	.9204	71-	.9434	83-	.9665	95-	.9906
-2	.8769	-2	.8985	-2	.9207	-2	.9437	-2	.9669	-2	.9910
-4	.8772	-4	.8989	-4	.9210	-4	.9441	-4	.9673	-4	.9914
-6	.8776	-6	.8992	-6	.9214	-6	.9445	-6	.9677	-6	.9918
-8	.8779	-8	.8996	-8	.9218	-8	.9448	-8	.9681	-8	.9922
36-	.8783	48-	.9000	60-	.9222	72-	.9452	84-	.9685	96-	.9926
-2	.8786	-2	.9004	-2	.9226	-2	.9456	-2	.9689	-2	.9930
-4	.8790	-4	.9008	-4	.9229	-4	.9460	-4	.9693	-4	.9934
-6	.8793	-6	.9011	-6	.9233	-6	.9464	-6	.9697	-6	.9938
-8	.8797	-8	.9015	-8	.9237	-8	.9468	-8	.9701	-8	.9942
37-	.8800	49-	.9019	61-	.9241	73-	.9472	85-	.9705	97-	.9946
-2	.8804	-2	.9023	-2	.9244	-2	.9476	-2	.9709	-2	.9950
-4	.8807	-4	.9028	-4	.9248	-4	.9480	-4	.9713	-4	.9954
-6	.8811	-6	.9030	-6	.9252	-6	.9484	-6	.9718	-6	.9958
-8	.8814	-8	.9034	-8	.9255	-8	.9488	-8	.9722	-8	.9962
38-	.8818	50-	.9038	62-	.9259	74-	.9492	86-	.9726	98-	.9966
-2	.8822	-2	.9041	-2	.9263	-2	.9496	-2	.9730	-2	.9970
-4	.8825	-4	.9045	-4	.9267	-4	.9499	-4	.9734	-4	.9974
-6	.8829	-6	.9049	-6	.9270	-6	.9503	-6	.9738	-6	.9978
-8	.8832	-8	.9052	-8	.9274	-8	.9507	-8	.9742	-8	.9982
39-	.8836	51-	.9056	63-	.9278	75-	.9511	87-	.9746	99-	.9986
-2	.8840	-2	.9060	-2	.9282	-2	.9515	-2	.9750	-2	.9990
-4	.8843	-4	.9064	-4	.9286	-4	.9519	-4	.9754	-4	.9993
-6	.8847	-6	.9067	-6	.9291	-6	.9522	-6	.9758	-6	.9997
-8	.8850	-8	.9071	-8	.9295	-8	.9526	-8	.9762	-8	1.0000
40-	.8854	52-	.9075	64-	.9299	76-	.9530	88-	.9766	100-	
-2	.8858	-2	.9079	-2	.9302	-2	.9534	-2	.9770		
-4	.8861	-4	.9082	-4	.9306	-4	.9538	-4	.9774		
-6	.8865	-6	.9085	-6	.9310	-6	.9542	-6	.9778		
-8	.8869	-8	.9089	-8	.9314	-8	.9546	-8	.9782		
41-	.8872	53-	.9093	65-	.9318	77-	.9550	89-	.9786		
-2	.8876	-2	.9097	-2	.9322	-2	.9553	-2	.9790		
-4	.8879	-4	.9100	-4	.9326	-4	.9557	-4	.9794		
-6	.8883	-6	.9104	-6	.9329	-6	.9561	-6	.9798		
-8	.8886	-8	.9107	-8	.9333	-8	.9565	-8	.9802		

No. 20.

COMMON DECIMALS AND EQUIVALENT FRACTIONS.

$\cdot 25 = \frac{1}{4}$	$\cdot 125 = \frac{1}{8}$	$\cdot 01 = \frac{1}{100}$	$\cdot 0033 = \frac{1}{300}$
$\cdot 5 = \frac{1}{2}$	$\cdot 1 = \frac{1}{10}$	$\cdot 333 = \frac{1}{3}$	$\cdot 0625 = \frac{1}{16}$
$\cdot 75 = \frac{3}{4}$	$\cdot 05 = \frac{1}{20}$	$\cdot 2 = \frac{1}{5}$	$\cdot 0312 = \frac{1}{32}$

No. 21.

ALIQOT PARTS.

Parts.	Of a Pound.	Of a Shilling.	Of 1 lb.	Of 1 cwt.
$\frac{1}{2}$ or $\cdot 5$	s. d. 10 0	d. 6	os. 8	grs. 2
" $\cdot 25$	5 0	3	4	1
" $\cdot 75$	15 0	9	12	3
" $\cdot 125$	2 6	$1\frac{1}{2}$	2	$0\frac{1}{2}$

1s. = $\frac{1}{20}$, or $\cdot 05$ of £1; 2s. = $\frac{1}{10}$, or $\cdot 1$ of £1; 3s. 4d. = $\frac{1}{6}$, or $\cdot 166$ of £1;
 6s. 8d. = $\frac{1}{3}$, or $\cdot 333$ of £1; 2d. = $\frac{1}{100}$, or $\cdot 01$ of £1; 4d. = $\frac{1}{50}$, or $\cdot 02$ of £1;
 8d. = $\frac{1}{25}$, or $\cdot 04$ of £1; 1d. = $\frac{1}{100}$, or $\cdot 01$ of £1; $\frac{1}{2}$ d. = $\frac{1}{200}$, or $\cdot 005$ of £1.

No. 22.

DECIMALS OF £1, REPRESENTING THE DIFFERENT RATES OF DUTY.

Rate.	Decimal.	Fraction.	Duty.
s. d. 0 $1\frac{1}{2}$	$\cdot 00825$	$\frac{1}{120}$	1 lb. paper, hard soap, or mileage rate.
0 1	$\cdot 004166$	$\frac{1}{240}$	1 lb. soft soap.
2 0	$\cdot 1$	$\frac{1}{10}$	1 bushel bear or big malt.
2 7	$\cdot 1292$	$\frac{1}{77}$	1 bushel common malt.
2 $8\frac{1}{2}$	$\cdot 135$	$\frac{1}{74}$	Ditto, with 5 per cent.
7 10	$\cdot 8916$	$\frac{1}{112}$	1 gallon spirits in England.
8 8	$\cdot 1833$	$\frac{1}{55}$	1 " " Scotland.
2 8	$\cdot 1333$	$\frac{1}{75}$	1 " " Ireland.

No. 23.

DECIMALS OF PER CENTAGES.

Per Cent.	Decimal and Fraction.	Per Cent.	Decimal and Fraction.	Per Cent.	Decimal and Fraction.	Per Cent.	Decimal and Fraction.
$\frac{1}{2}$	$\cdot 005$ or $\frac{1}{200}$	3	$\cdot 03$ or $\frac{3}{100}$	$4\frac{1}{2}$	$\cdot 045$ or $\frac{9}{200}$	10	$\cdot 1$ or $\frac{1}{10}$
1	$\cdot 01$ or $\frac{1}{100}$	$3\frac{1}{2}$	$\cdot 035$ or $\frac{7}{200}$	5	$\cdot 05$ or $\frac{1}{20}$	15	$\cdot 15$ or $\frac{3}{20}$
$2\frac{1}{2}$	$\cdot 025$ or $\frac{1}{40}$	4	$\cdot 04$ or $\frac{1}{25}$	6	$\cdot 06$ or $\frac{3}{50}$	25	$\cdot 25$ or $\frac{1}{4}$

No. 24.

TABLE OF FACTORS FOR SALARIES.

Per Year.	Factor for a Day.			Per Year.	Factor for a Day.			Per Year.	Factor for a Day.			Per Year.	Factor for a Day.		
	Common Year.	Leap Year.	Value in a common Year.		Common Year.	Leap Year.	Value in a common Year.		Common Year.	Leap Year.	Value in a common Year.		Common Year.	Leap Year.	Value in a common Year.
1	002739	002732	0 0 9	52	142466	142076	2 10 4	150	410659	409836	0 8 2	24	106659	106286	0 8 2
5	013608	013601	0 0 7	78	213659	213114	4 3 2	200	547946	546448	0 10 11	34	154794	154394	0 10 11
10	027397	027322	0 0 7	80	219178	218579	4 4 4	250	684931	683060	0 13 8	37	191739	191286	0 13 8
15	041096	040983	0 10 8	85	232877	232240	4 8 8	300	821918	819672	0 16 5	42	228728	228186	0 16 5
20	054794	054644	1 1 1	90	246575	245901	4 11 4	350	958904	956284	0 19 2	47	265717	265086	0 19 2
25	071233	071038	1 8 10	100	273973	273234	5 5 9	400	1096590	1092896	1 1 11	52	303156	302486	1 1 11
30	082192	081967	1 7 11	115	310669	314207	6 5 9	450	1232574	1229688	1 4 7	57	340655	340186	1 4 7
35	104109	103825	2 1 1	150	328767	327866	6 7 8	500	1369863	1366120	1 7 4	62	381654	381186	1 7 4
50	136986	136612	2 8 1	140	383562	382513	7 8 8	600	1643836	1639344	1 12 10	67	434653	434186	1 12 10

No. 25.

LIFE ASSURANCE. TABLE SHOWING THE PREMIUMS TO BE PAID BY PERSONS OF THE UNDERMENTIONED AGES, NEXT BIRTH-DAY, TO ASSURE £100 AT DEATH.

Age.	Annually.			Eight times a Year.	Age.	Annually.			Eight times a Year.	Age.	Annually.			Eight times a Year.		
	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	
16	1	18	0	4	10	33	2	14	10	0	7	0	50	4	8	0
17	1	19	1	5	0	34	2	16	1	0	7	2	51	4	9	9
18	2	0	0	5	1	35	2	17	5	0	7	4	52	4	12	7
19	2	0	11	5	3	36	2	18	10	0	7	7	53	4	15	7
20	2	1	10	5	4	37	3	0	4	0	7	9	54	4	18	9
21	2	2	8	5	6	38	3	1	11	0	7	11	55	5	2	1
22	2	3	6	5	7	39	3	3	6	0	8	2	56	5	5	8
23	2	4	4	5	8	40	3	5	8	0	8	5	57	5	9	5
24	2	5	3	5	9	41	3	7	0	0	8	7	58	5	13	5
25	2	6	2	5	11	42	3	8	10	0	8	10	59	5	17	8
26	2	7	1	6	0	43	3	10	8	0	9	1	60	6	2	3
27	2	8	1	6	2	44	3	12	8	0	9	4	61	6	7	1
28	2	9	1	6	3	45	3	14	9	0	9	8	62	6	12	2
29	2	10	1	6	5	46	3	17	0	0	9	11	63	6	17	10
30	2	11	8	6	7	47	3	18	3	0	10	3	64	7	3	10
31	2	12	4	6	9	48	4	1	8	0	10	6	65	7	10	5
32	2	13	7	6	10	49	4	4	3	0	10	11				

No. 26.

TABLE OF 2½ PER CENT. AND 3d. IN THE £ ON SUMS UNDER £1.

At 2½ per Cent.								At 3d. in the £1.							
Sum.	Per Ct.	Sum.	Per Ct.	Sum.	Per Ct.	Sum.	Per Ct.	Sum.	Per Ct.	Sum.	Per Ct.	Sum.	Per Ct.	Sum.	Per Ct.
s. d.	d.	s. d.	d.	s. d.	d.	s. d.	d.	s. d.	d.	s. d.	d.	s. d.	d.	s. d.	d.
0 10	0 ½	5 10	1 ½	10 10	2 ½	15 10	4 ½	1 8	0 ½	11 8	1 ½	13 4	2 ½	18 4	2 ½
1 8	0 ½	6 8	2 ½	11 8	3 ½	16 8	5 ½	3 4	0 ½	13 4	2 ½	15 0	2 ½	20 0	3 ½
2 6	0 ½	7 6	2 ½	12 6	3 ½	17 6	5 ½	6 8	1 ½	16 8	2 ½	18 4	2 ½	22 0	3 ½
3 4	1 ½	8 4	2 ½	13 4	4 ½	18 4	5 ½	8 4	1 ½	18 4	2 ½	20 0	3 ½	24 0	4 ½
4 2	1 ½	9 2	2 ½	14 2	4 ½	19 2	5 ½	10 0	1 ½	20 0	3 ½	22 0	3 ½	26 0	4 ½
5 0	1 ½	10 0	3 ½	15 0	4 ½	20 0	6 ½								

The first part of this Table, (=6d. in the pound), shows the deductions towards Superannuation Allowances; and the second (=1½ per cent.) is the amount of Allowances made to Postmasters.

No. 27.

TABLE OF 5 PER CENT.

s. d.	s. d.	£	£ s. d.	£	£ s. d.	£	£ s. d.	£	£ s. d.	£	£ s. d.
0 5	0 0 04	1	0 1 0	51	2 11 0	101	5 1 0	155	7 15 0		
0 10	0 0 04	2	0 2 0	52	2 12 0	102	5 2 0	156	8 0 0		
1 3	0 0 04	3	0 3 0	53	2 13 0	103	5 3 0	157	8 5 0		
1 8	0 0 1	4	0 4 0	54	2 14 0	104	5 4 0	158	8 10 0		
2 1	0 0 12	5	0 5 0	55	2 15 0	105	5 5 0	159	8 15 0		
2 6	0 0 14	6	0 6 0	56	2 16 0	106	5 6 0	160	9 0 0		
2 11	0 0 14	7	0 7 0	57	2 17 0	107	5 7 0	161	9 5 0		
3 4	0 0 2	8	0 8 0	58	2 18 0	108	5 8 0	162	9 10 0		
3 9	0 0 24	9	0 9 0	59	2 19 0	109	5 9 0	163	9 15 0		
4 2	0 0 24	10	0 10 0	60	3 0 0	110	5 10 0	164	10 0 0		
4 7	0 0 24	11	0 11 0	61	3 1 0	111	5 11 0	165	11 5 0		
5 0	0 0 3	12	0 12 0	62	3 2 0	112	5 12 0	166	12 10 0		
5 5	0 0 34	13	0 13 0	63	3 3 0	113	5 13 0	167	13 15 0		
5 10	0 0 34	14	0 14 0	64	3 4 0	114	5 14 0	168	15 0 0		
6 3	0 0 34	15	0 15 0	65	3 5 0	115	5 15 0	169	16 5 0		
6 8	0 0 4	16	0 16 0	66	3 6 0	116	5 16 0	170	17 10 0		
7 1	0 0 42	17	0 17 0	67	3 7 0	117	5 17 0	171	18 15 0		
7 6	0 0 44	18	0 18 0	68	3 8 0	118	5 18 0	172	20 0 0		
7 11	0 0 44	19	0 19 0	69	3 9 0	119	5 19 0	173	21 5 0		
8 4	0 0 5	20	1 0 0	70	3 10 0	120	6 0 0	174	22 10 0		
8 9	0 0 54	21	1 1 0	71	3 11 0	121	6 1 0	175	23 15 0		
9 2	0 0 54	22	1 2 0	72	3 12 0	122	6 2 0	176	25 0 0		
9 7	0 0 54	23	1 3 0	73	3 13 0	123	6 3 0	177	26 5 0		
10 0	0 0 6	24	1 4 0	74	3 14 0	124	6 4 0	178	27 10 0		
10 5	0 0 64	25	1 5 0	75	3 15 0	125	6 5 0	179	28 15 0		
10 10	0 0 64	26	1 6 0	76	3 16 0	126	6 6 0	180	30 0 0		
11 3	0 0 64	27	1 7 0	77	3 17 0	127	6 7 0	181	31 5 0		
11 8	0 0 7	28	1 8 0	78	3 18 0	128	6 8 0	182	32 10 0		
12 1	0 0 74	29	1 9 0	79	3 19 0	129	6 9 0	183	33 15 0		
12 6	0 0 74	30	1 10 0	80	4 0 0	130	6 10 0	184	35 0 0		
12 11	0 0 74	31	1 11 0	81	4 1 0	131	6 11 0	185	36 5 0		
13 4	0 0 8	32	1 12 0	82	4 2 0	132	6 12 0	186	37 10 0		
13 9	0 0 84	33	1 13 0	83	4 3 0	133	6 13 0	187	38 15 0		
14 2	0 0 84	34	1 14 0	84	4 4 0	134	6 14 0	188	40 0 0		
14 7	0 0 84	35	1 15 0	85	4 5 0	135	6 15 0	189	41 5 0		
15 0	0 0 9	36	1 16 0	86	4 6 0	136	6 16 0	190	43 10 0		
15 5	0 0 94	37	1 17 0	87	4 7 0	137	6 17 0	191	43 15 0		
15 10	0 0 94	38	1 18 0	88	4 8 0	138	6 18 0	192	45 0 0		
16 3	0 0 94	39	1 19 0	89	4 9 0	139	6 19 0	193	46 5 0		
16 8	0 0 10	40	2 0 0	90	4 10 0	140	7 0 0	194	47 10 0		
17 1	0 0 104	41	2 1 0	91	4 11 0	141	7 1 0	195	48 15 0		
17 6	0 0 104	42	2 2 0	92	4 12 0	142	7 2 0	196	50 0 0		
17 11	0 0 104	43	2 3 0	93	4 13 0	143	7 3 0				
18 4	0 0 11	44	2 4 0	94	4 14 0	144	7 4 0				
18 9	0 0 114	45	2 5 0	95	4 15 0	145	7 5 0				
19 2	0 0 114	46	2 6 0	96	4 16 0	146	7 6 0				
19 7	0 0 114	47	2 7 0	97	4 17 0	147	7 7 0				
		48	2 8 0	98	4 18 0	148	7 8 0				
		49	2 9 0	99	4 19 0	149	7 9 0				
		50	2 10 0	100	5 0 0	150	7 10 0				

This Table shows the amount of additional Duty imposed upon various commodities at 25 per cent., or 1s. in the pound; also, Interest at the rate of 5 per cent. per annum, &c.—(See p. 37.)

No. 28.

COMMISSION TABLE.

<i>Am't.</i>	<i>At ½ per Cent.</i>			<i>At ¼ per Cent.</i>			<i>At ¼ per Cent.</i>			<i>At 1 per Cent.</i>		
	<i>£</i>	<i>s.</i>	<i>d.</i>	<i>£</i>	<i>s.</i>	<i>d.</i>	<i>£</i>	<i>s.</i>	<i>d.</i>	<i>£</i>	<i>s.</i>	<i>d.</i>
1	0	0	0½	0	0	0½	0	0	1	0	0	1½
2	0	0	0½	0	0	1	0	0	2½	0	0	3½
3	0	0	0½	0	0	1½	0	0	3½	0	0	5½
4	0	0	1	0	0	2½	0	0	4½	0	0	7
5	0	0	1½	0	0	3	0	0	6	0	0	9
6	0	0	1½	0	0	3½	0	0	7	0	0	10½
7	0	0	2	0	0	4	0	0	8½	0	1	0½
8	0	0	2½	0	0	4½	0	0	9½	0	1	2½
9	0	0	2½	0	0	5½	0	0	10½	0	1	4
10	0	0	3	0	0	6	0	1	0	0	1	6
20	0	0	6	0	1	0	0	2	0	0	3	0
30	0	0	9	0	1	8	0	3	0	0	4	6
40	0	1	0	0	2	0	0	4	0	0	6	0
50	0	1	3	0	2	6	0	5	0	0	7	6
60	0	1	6	0	3	0	0	6	0	0	9	0
70	0	1	9	0	3	6	0	7	0	0	10	6
80	0	2	0	0	4	0	0	8	0	0	12	0
90	0	2	3	0	4	6	0	9	0	0	13	6
100	0	2	6	0	5	0	0	10	0	0	15	0
200	0	5	0	0	10	0	1	0	0	1	10	0
300	0	7	6	0	15	0	1	10	0	2	5	0
400	0	10	0	1	0	0	2	0	0	3	0	0
500	0	12	6	1	5	0	2	10	0	3	15	0
600	0	15	0	1	10	0	3	0	0	4	10	0
700	0	17	6	1	15	0	3	10	0	5	5	0
800	1	0	0	2	0	0	4	0	0	6	0	0
900	1	2	6	2	5	0	4	10	0	6	15	0
1000	1	5	0	2	10	0	5	0	0	7	10	0
2000	2	10	0	5	0	0	10	0	0	15	0	0
3000	3	15	0	7	10	0	15	0	0	22	10	0
4000	5	0	0	10	0	0	20	0	0	30	0	0
5000	6	5	0	12	10	0	25	0	0	37	10	0
10000	12	10	0	25	0	0	50	0	0	75	0	0

No. 29.

INCOME TAX AT 7d. IN THE POUND.

<i>s.</i>	<i>d.</i>	<i>s.</i>	<i>d.</i>	<i>s.</i>	<i>d.</i>	<i>s.</i>	<i>d.</i>	<i>£</i>	<i>s.</i>	<i>d.</i>	<i>£</i>	<i>s.</i>	<i>d.</i>	<i>£</i>	<i>s.</i>	<i>d.</i>	<i>£</i>	<i>s.</i>	<i>d.</i>
9	0½	5	9½	10	9½	15	9½	1	0	7	8	0	4	8	60	1	15	0	400
6	0½	6	6½	11	6½	16	6½	2	1	2	9	0	5	3	70	2	0	10	500
2	0½	7	2½	12	2½	17	2½	3	1	9	10	0	5	10	80	2	6	8	600
11	1	7	11½	12	11½	17	11½	4	2	4	20	0	11	8	90	2	12	6	700
7	1½	8	7½	13	7½	18	7½	5	2	11	30	0	17	6	100	2	18	4	800
4	1½	9	4½	14	4½	19	4½	6	3	6	40	1	3	4	200	5	16	8	900
0	1½	10	0½	15	0½	20	0½	7	4	1	50	1	9	2	300	8	15	0	1000

No. 30.

DIVISORS, FACTORS, AND GAUGE POINTS.

		SQUARE SOLIDS.			ROUND SOLIDS.			
		Square or Prism.	Pyra- mid.	Frustum or Prismoid.	Circle or Cy- linder.	Globe or Sphere.	Cone.	Frus- tum.
Divisors.	Cubic Inches	1'	5'	6'	1'2732	1'90985	5'8197	7'6394
	Gallons	277'274	831'82	1663'64	353'036	529'654	1059'108	2118'216
	Bushels	2218'192	665'457	13309'15	2924'79	4336'48	8472'87	16945'74
	Soap, com., hard hot . .	28'	94'	185'	35'35	53'475	106'55	213'
	Ditto cold	27'14	81'42	162'84	34'55	51'232	103'664	207'327
Factors.	Cubic Inches	1'	333333	16666	786398	5236	2618	1309
	Gallons	000806	001202	000601	002832	0018494	006944	0004721
	Bushels	000451	00015	000075	000354	000236	000118	000059
	Soap, com., hard hot . .	0357	0119	00596	02905	0187	00935	004675
	Ditto cold	0368	0123	00613	02894	01929	00964	004823
Gauge Points.	Cubic Inches	1'	173	245	1'128	1'393	1'95441	2'764
	Gallons	16'65	26'94	40'79	18'79	23'	32'5441	46'02
	Bushels	47'10	81'57	115'36	53'14	65'06	92'049	130'17
	Soap, com., hard hot . .	5'3	9'16	12'96	5'97	7'31	10'34	14'03
	Ditto cold	5'21	9'02	12'72	5'87	7'2	10'19	14'4

The *Square Divisor* for Soap, high pressure hot, is 26'76; cold, 25'91; *Silicated* hot, 24'04; cold, 23'30. The *Factor* for Soap, high pressure hot, is .0873; cold, .0886; *Silicated* hot, .0416; cold, .04292. The *Areas of Soap Frames* are—common hard, hot, 24'107; cold, 24'87; high pressure, hot, 25'224; cold, 26'061; *Silicated* hot, 28'078; cold, 28'97.

For finding the *Areas of Circles* from *Circumferences*, the *Divisor* for gallons is 3484'22; for bushels, 27873'72. The *Factor* for gallons is .000287; for bushels, .0000359. The *Gauge-point* for gallons is 59; for bushels, 167. For finding the *Area of Spheres* from *Circumferences* the *Divisor* for gallons is 1663'6468; the *Factor*, .0006011; and the *Gauge-point*, 40'8.

The *Constant Gauge-points* for finding areas on the line M D (being the proportions of different measures to a bushel) are, for bushels, 1; for gallons, 8; common hard soap, hot, 79'2; cold, 81'7; high pressure, hot, 82'9; cold, 85'6; *silicated*, hot, 92'3; cold, 95'2. And for finding the areas of circles from *diameters*, for gallons, 6'283; and for bushels, .7854.

No. 31.

TABLE FOR FINDING THE AREAS OF REGULAR POLYGONS.

	Sides.	Degrees.	Inches.	Gallons.	Bushels.
Trigon	3	120	4330127	0015616	0001952
Tetragon	4	90	1'0000000	0036065	0004508
Pentagon	5	72	1'7204774	0062049	0007756
Hexagon	6	60	2'5980762	0083701	0011713
Heptagon	7	41 $\frac{1}{2}$	3'6339124	0181058	0016382
Octagon	8	45	4'8284271	0174139	0021767
Nonagon	9	80	6'1818242	0222360	0027869
Decagon	10	86	7'6942068	0277496	0034687
Undecagon	11	82 $\frac{1}{11}$	9'9656411	0387775	0042222
Dodecadon	12	80	11'1961524	0403794	0050474

No. 32.

TABLE OF LOGARITHMS.

No.	0	1	2	3	4	5	6	7	8	9	No.
1	000000	041393	079181	113943	146128	176091	204120	230449	255273	278754	1
2	301030	322219	342423	361728	380211	397940	414973	431364	447168	462396	2
3	477121	491362	505150	518514	531479	544068	556303	568202	579784	591066	3
4	602060	612784	623249	633468	643453	653213	662758	672098	681241	690196	4
5	698970	707570	716003	724276	732394	740363	748198	755875	763428	770862	5
6	778151	785330	792392	799341	806180	812913	819544	826075	832509	838849	6
7	845098	851258	857332	863323	869232	875061	880814	886491	892096	897627	7
8	903090	908485	913814	919078	924279	929419	934498	939519	944483	949390	8
9	954243	959041	963788	968483	973128	977724	982271	986772	991226	995636	9
10	000000	004321	008600	012837	017033	021189	025306	029384	033424	037428	10
11	041393	045323	049218	053078	056906	060698	064458	068186	071882	075547	11
12	079181	082785	086366	089905	093422	096910	100371	103804	107210	110580	12
13	113943	117271	120574	123852	127105	130334	133539	136721	139879	143015	13
14	146128	149219	152288	155336	158362	161368	164353	167317	170262	173186	14
15	176091	178977	181844	184691	187521	190332	193125	195900	198657	201397	15
16	204120	206826	209515	212188	214844	217484	220108	222716	225309	227887	16
17	230449	232996	235628	238046	240549	243038	245513	247973	250420	252853	17
18	255273	257679	260071	262451	264818	267172	269513	271842	274158	276462	18
19	278754	281033	283301	285567	287820	290065	292296	294466	296665	298853	19
20	301030	303196	305351	307496	309630	311754	313867	315970	318063	320146	20
21	322219	324292	326336	328390	330414	332438	334454	336460	338456	340444	21
22	342423	344392	346353	348305	350248	352183	354108	356026	357935	359835	22
23	361728	363612	365488	367356	369216	371068	372912	374748	376577	378398	23
24	380211	382017	383815	385606	387390	389166	390935	392697	394452	396199	24
25	397940	399674	401401	403121	404834	406540	408240	409933	411620	413300	25
26	414973	416641	418301	419956	421604	423246	424882	426511	428135	429752	26
27	431364	432969	434569	436163	437751	439333	440909	442480	444045	445604	27
28	447158	448706	450249	451788	453318	454845	456366	457882	459393	460898	28
29	462396	463898	465388	466868	468347	469822	471292	472756	474216	475671	29
30	477121	478566	480007	481443	482874	484300	485721	487138	488551	489959	30
31	491362	492760	494155	495544	496930	498311	499687	501069	502427	503791	31
32	505150	506505	507856	509203	510545	511883	513218	514548	515874	517196	32
33	518514	519828	521138	522444	523746	525045	526339	527630	528917	530200	33
34	531479	532764	534026	535294	536556	537819	539076	540329	541579	542825	34
35	544068	545307	546543	547775	549003	550228	551450	552668	553883	555094	35
36	556303	557507	558709	559907	561101	562293	563481	564666	565849	567028	36
37	568202	569374	570543	571709	572872	574031	575188	576341	577492	578639	37
38	579784	580925	582063	583199	584331	585461	586587	587711	588832	589950	38
39	591065	592177	593286	594393	595496	596597	597695	598791	599885	600973	39
40	602060	603144	604226	605306	606381	607455	608526	609594	610660	611723	40
41	612784	613842	614897	615950	617000	618048	619093	620136	621176	622214	41
42	623249	624282	625312	626340	627366	628389	629410	630428	631444	632457	42
43	633468	634477	635484	636488	637490	638489	639486	640481	641474	642465	43
44	643453	644439	645422	646404	647383	648360	649335	650308	651278	652246	44
45	653213	654177	655138	656098	657056	658011	658965	659916	660866	661813	45
46	662758	663701	664642	665581	666518	667453	668386	669317	670246	671173	46
47	672098	673021	673942	674861	675778	676694	677607	678518	679428	680336	47
48	681241	682145	683047	683947	684845	685742	686636	687529	688420	689309	48
49	690196	691081	691965	692847	693727	694605	695482	696356	697229	698101	49
50	698970	699838	700704	701568	702431	703291	704151	705008	705864	706718	50
No.	0	1	2	3	4	5	6	7	8	9	No.

TABLE OF LOGARITHMS.—continued.

No.	0	1	2	3	4	5	6	7	8	9.	No.
51	707570	708421	709270	710117	710963	711807	712650	713491	714330	715167	51
52	716003	716838	717671	718502	719331	720159	720986	721811	722634	723456	52
53	724276	725095	725912	726727	727541	728354	729165	729974	730782	731589	53
54	732394	733197	733999	734800	735599	736397	737193	737987	738781	739572	54
55	740863	741152	741939	742725	743510	744298	745075	745855	746634	747412	55
56	748198	748963	749736	750506	751279	752048	752816	753583	754348	755112	56
57	756875	757636	758396	759155	759912	760668	761422	762176	762928	763679	57
58	765428	766176	766923	767669	768413	769156	769898	770639	771379	772118	58
59	773852	774587	775322	776055	776786	777517	778247	778974	779701	780427	59
60	781151	781874	782596	783317	784037	784755	785472	786189	786904	787617	60
61	788330	789041	789751	790460	791168	791875	792581	793285	793988	794691	61
62	795392	796092	796790	797488	798185	798880	799574	800268	800961	801653	62
63	802344	803035	803725	804414	805102	805789	806475	807160	807844	808527	63
64	809209	809892	810574	811255	811935	812614	813292	813969	814645	815320	64
65	815994	816668	817341	818013	818684	819354	820023	820691	821358	822024	65
66	822689	823354	824018	824681	825343	826004	826664	827323	827981	828638	66
67	829294	829951	830607	831262	831916	832569	833221	833872	834522	835171	67
68	835819	836466	837112	837757	838401	839044	839686	840327	840968	841607	68
69	842245	842882	843518	844153	844787	845420	846052	846683	847313	847942	69
70	848570	849198	849825	850451	851076	851700	852323	852945	853566	854186	70
71	854805	855423	856040	856656	857271	857885	858498	859110	859721	860331	71
72	860940	861549	862157	862764	863370	863975	864579	865182	865784	866386	72
73	866987	867588	868188	868787	869385	869982	870578	871173	871767	872360	73
74	872952	873544	874135	874725	875314	875902	876489	877075	877660	878244	74
75	878827	879410	879992	880573	881153	881732	882310	882887	883463	884038	75
76	884612	885186	885759	886331	886902	887472	888041	888609	889176	889742	76
77	890307	890872	891436	891999	892561	893122	893682	894241	894799	895356	77
78	895912	896468	897023	897577	898130	898682	899233	899783	900332	900880	78
79	901427	901974	902520	903065	903609	904152	904694	905235	905775	906314	79
80	906852	907389	907925	908460	908994	909527	910059	910590	911120	911649	80
81	912177	912704	913230	913755	914279	914802	915324	915845	916365	916884	81
82	917402	917919	918435	918950	919464	919977	920489	921000	921510	922019	82
83	922527	923034	923540	924045	924549	925052	925554	926056	926557	927057	83
84	927556	928054	928551	929047	929542	930036	930529	931021	931512	932002	84
85	932491	932979	933466	933952	934437	934921	935404	935886	936367	936847	85
86	937326	937805	938283	938760	939236	939711	940185	940658	941130	941599	86
87	942067	942534	942999	943463	943926	944388	944849	945308	945766	946223	87
88	946679	947135	947590	948044	948497	948949	949400	949850	950300	950748	88
89	951195	951641	952086	952530	952972	953413	953853	954292	954730	955167	89
90	955603	956039	956474	956908	957341	957773	958204	958634	959063	959491	90
91	959918	960345	960771	961196	961620	962043	962465	962886	963306	963725	91
92	964143	964560	964976	965390	965803	966215	966626	967036	967445	967853	92
93	968260	968667	969073	969478	969882	970285	970687	971088	971488	971887	93
94	972284	972682	973079	973475	973870	974264	974657	975049	975440	975830	94
95	976220	976609	976997	977384	977769	978153	978536	978918	979299	979679	95
96	980058	980436	980813	981189	981564	981938	982311	982683	983054	983424	96
97	983793	984161	984528	984894	985259	985623	985986	986348	986709	987069	97
98	987428	987786	988143	988499	988854	989208	989561	989913	990264	990614	98
99	990963	991311	991658	992004	992349	992692	993034	993375	993715	994054	99
100	994392	994729	995065	995400	995734	996067	996399	996730	997060	997389	100

No. 33.

TABLE OF THE AREAS OF CIRCULAR SEGMENTS.

Height.	Area.	Height.	Area.	Height.	Area.	Height.	Area.	Height.	Area.
.001	.000042	.051	.015119	.101	.041476	.151	.074589	.201	.112624
.002	.000119	.052	.015561	.102	.042080	.152	.075306	.202	.113426
.003	.000219	.053	.016007	.103	.042687	.153	.076026	.203	.114230
.004	.000337	.054	.016457	.104	.043296	.154	.076747	.204	.115035
.005	.000470	.055	.016911	.105	.043908	.155	.077469	.205	.115842
.006	.000618	.056	.017369	.106	.044522	.156	.078194	.206	.116650
.007	.000779	.057	.017831	.107	.045139	.157	.078921	.207	.117460
.008	.000951	.058	.018296	.108	.045759	.158	.079649	.208	.118271
.009	.001135	.059	.018766	.109	.046381	.159	.080380	.209	.119084
.010	.001329	.060	.019239	.110	.047005	.160	.081112	.210	.119897
.011	.001533	.061	.019716	.111	.047632	.161	.081846	.211	.120712
.012	.001746	.062	.020196	.112	.048262	.162	.082582	.212	.121529
.013	.001969	.063	.020691	.113	.048894	.163	.083320	.213	.122347
.014	.002199	.064	.021168	.114	.049528	.164	.084059	.214	.123167
.015	.002438	.065	.021659	.115	.050165	.165	.084801	.215	.123988
.016	.002685	.066	.022154	.116	.050804	.166	.085544	.216	.124810
.017	.002940	.067	.022652	.117	.051446	.167	.086289	.217	.125634
.018	.003202	.068	.023154	.118	.052090	.168	.087036	.218	.126459
.019	.003471	.069	.023659	.119	.052736	.169	.087785	.219	.127285
.020	.003748	.070	.024168	.120	.053385	.170	.088535	.220	.128113
.021	.004031	.071	.024680	.121	.054036	.171	.089287	.221	.128942
.022	.004322	.072	.025195	.122	.054689	.172	.090041	.222	.129773
.023	.004618	.073	.025714	.123	.055345	.173	.090797	.223	.130605
.024	.004921	.074	.026236	.124	.056003	.174	.091554	.224	.131438
.025	.005230	.075	.026761	.125	.056663	.175	.092313	.225	.132272
.026	.005546	.076	.027289	.126	.057326	.176	.093074	.226	.133108
.027	.005867	.077	.027821	.127	.057991	.177	.093836	.227	.133945
.028	.006194	.078	.028356	.128	.058658	.178	.094601	.228	.134784
.029	.006527	.079	.028894	.129	.059327	.179	.095366	.229	.135624
.030	.006865	.080	.029435	.130	.059999	.180	.096134	.230	.136465
.031	.007209	.081	.029979	.131	.060672	.181	.096904	.231	.137307
.032	.007558	.082	.030526	.132	.061348	.182	.097674	.232	.138150
.033	.007913	.083	.031076	.133	.062026	.183	.098447	.233	.138995
.034	.008273	.084	.031629	.134	.062707	.184	.099221	.234	.139841
.035	.008638	.085	.032186	.135	.063389	.185	.099997	.235	.140688
.036	.009008	.086	.032745	.136	.064074	.186	.100774	.236	.141537
.037	.009383	.087	.033307	.137	.064760	.187	.101553	.237	.142387
.038	.009763	.088	.033872	.138	.065449	.188	.102334	.238	.143238
.039	.010148	.089	.034441	.139	.066140	.189	.103116	.239	.144091
.040	.010537	.090	.035011	.140	.066833	.190	.103900	.240	.144944
.041	.010931	.091	.035585	.141	.067528	.191	.104685	.241	.145799
.042	.011330	.092	.036162	.142	.068225	.192	.105472	.242	.146655
.043	.011734	.093	.036741	.143	.068924	.193	.106261	.243	.147512
.044	.012142	.094	.037323	.144	.069625	.194	.107051	.244	.148371
.045	.012554	.095	.037909	.145	.070328	.195	.107842	.245	.149230
.046	.012971	.096	.038497	.146	.071033	.196	.108636	.246	.150091
.047	.013392	.097	.039087	.147	.071741	.197	.109431	.247	.150953
.048	.013818	.098	.039680	.148	.072450	.198	.110226	.248	.151816
.049	.014247	.099	.040276	.149	.073161	.199	.111025	.249	.152680
.050	.014681	.100	.040875	.150	.073874	.200	.111823	.250	.153546

TABLE OF THE AREAS OF CIRCULAR SEGMENTS.—continued.

Height.	Area.	Height.	Area.	Height.	Area.	Height.	Area.	Height.	Area.
251	154412	301	199085	351	245934	401	294349	451	343777
252	155280	302	200003	352	246889	402	295330	452	344772
253	156149	303	200922	353	247845	403	296311	453	345768
254	157019	304	201841	354	248801	404	297292	454	346764
255	157890	305	202761	355	249757	405	298273	455	347759
256	158762	306	203683	356	250715	406	299255	456	348753
257	159636	307	204605	357	251673	407	300238	457	349752
258	160510	308	205527	358	252631	408	301220	458	350748
259	161386	309	206451	359	253590	409	302203	459	351745
260	162263	310	207376	360	254550	410	303187	460	352742
261	163140	311	208301	361	255510	411	304171	461	353739
262	164019	312	209227	362	256471	412	305155	462	354736
263	164899	313	210154	363	257433	413	306140	463	355732
264	165780	314	211083	364	258395	414	307125	464	356730
265	166663	315	212011	365	259357	415	308110	465	357727
266	167546	316	212940	366	260320	416	309095	466	358725
267	168430	317	213871	367	261284	417	310081	467	359723
268	169316	318	214802	368	262248	418	311068	468	360721
269	170202	319	215733	369	263213	419	312054	469	361719
270	171089	320	216666	370	264178	420	313041	470	362717
271	171978	321	217599	371	265144	421	314029	471	363715
272	172867	322	218533	372	266111	422	315016	472	364713
273	173758	323	219468	373	267078	423	316004	473	365712
274	174649	324	220404	374	268045	424	316992	474	366710
275	175542	325	221341	375	269013	425	317981	475	367709
276	176435	326	222277	376	269982	426	318970	476	368708
277	177330	327	223215	377	270951	427	319959	477	369707
278	178225	328	224154	378	271920	428	320948	478	370706
279	179122	329	225093	379	272890	429	321938	479	371705
280	180019	330	226033	380	273861	430	322928	480	372704
281	180918	331	226974	381	274832	431	323918	481	373703
282	181818	332	227915	382	275803	432	324909	482	374702
283	182718	333	228858	383	276775	433	325900	483	375702
284	183619	334	229801	384	277748	434	326892	484	376702
285	184521	335	230745	385	278721	435	327882	485	377701
286	185425	336	231689	386	279694	436	328874	486	378701
287	186329	337	232634	387	280668	437	329866	487	379700
288	187234	338	233580	388	281642	438	330858	488	380700
289	188140	339	234526	389	282617	439	331850	489	381699
290	189047	340	235473	390	283592	440	332843	490	382699
291	189955	341	236421	391	284568	441	333836	491	383699
292	190864	342	237369	392	285544	442	334829	492	384699
293	191775	343	238318	393	286521	443	335822	493	385699
294	192684	344	239268	394	287498	444	336816	494	386699
295	193596	345	240218	395	288476	445	337810	495	387699
296	194509	346	241169	396	289454	446	338804	496	388699
297	195422	347	242121	397	290432	447	339798	497	389699
298	196337	348	243074	398	291411	448	340793	498	390699
299	197252	349	244026	399	292390	449	341787	499	391699
300	198168	350	244980	400	293369	450	342782	500	392699

No. 34.

TABLE SHOWING THE CIRCUMFERENCES OF CIRCLES WITH THEIR CORRESPONDING DIAMETERS.

Circumference.	Diameter.	Circumference.	Diameter.	Circumference.	Diameter.	Circumference.	Diameter.	Circumference.	Diameter.	Circumference.	Diameter.	Circumference.	Diameter.
1	31881	51	1628881	101	321489	151	480648	201	638808	251	798868	301	958888
2	63862	52	1655212	102	324876	152	483681	202	642886	252	802141	302	962888
3	95843	53	1687043	103	327869	153	487014	203	646886	253	805324	303	966888
4	127824	54	1718874	104	331042	154	490197	204	650886	254	808507	304	970888
5	159805	55	1750705	105	334225	155	493380	205	654886	255	811690	305	974888
6	191786	56	1782536	106	337408	156	496563	206	658886	256	814873	306	978888
7	223767	57	1814367	107	340591	157	499746	207	662886	257	818056	307	982888
8	255748	58	1846198	108	343774	158	502929	208	666886	258	821239	308	986888
9	287729	59	1878029	109	346957	159	506112	209	670886	259	824422	309	990888
10	319710	60	1909860	110	350140	160	509295	210	674886	260	827605	310	994888
11	351691	61	1941691	111	353323	161	512478	211	678886	261	830788	311	998888
12	383672	62	1973522	112	356506	162	515661	212	682886	262	833971	312	1002888
13	415653	63	2005353	113	359689	163	518844	213	686886	263	837154	313	1006888
14	447634	64	2037184	114	362872	164	522027	214	690886	264	840337	314	1010888
15	479615	65	2069015	115	366055	165	525210	215	694886	265	843520	315	1014888
16	511596	66	2100846	116	369238	166	528393	216	698886	266	846703	316	1018888
17	543577	67	2132677	117	372421	167	531576	217	702886	267	849886	317	1022888
18	575558	68	2164508	118	375604	168	534759	218	706886	268	853069	318	1026888
19	607539	69	2196339	119	378787	169	537942	219	710886	269	856252	319	1030888
20	639520	70	2228170	120	381970	170	541125	220	714886	270	859435	320	1034888
21	671501	71	2260001	121	385153	171	544308	221	718886	271	862618	321	1038888
22	703482	72	2291832	122	388336	172	547491	222	722886	272	865801	322	1042888
23	735463	73	2323663	123	391519	173	550674	223	726886	273	868984	323	1046888
24	767444	74	2355494	124	394702	174	553857	224	730886	274	872167	324	1050888
25	799425	75	2387325	125	397885	175	557040	225	734886	275	875350	325	1054888
26	831406	76	2419156	126	401068	176	560223	226	738886	276	878533	326	1058888
27	863387	77	2450987	127	404251	177	563406	227	742886	277	881716	327	1062888
28	895368	78	2482818	128	407434	178	566589	228	746886	278	884899	328	1066888
29	927349	79	2514649	129	410617	179	569772	229	750886	279	888082	329	1070888
30	959330	80	2546480	130	413800	180	572955	230	754886	280	891265	330	1074888
31	991311	81	2578311	131	416983	181	576138	231	758886	281	894448	331	1078888
32	1023292	82	2610142	132	420166	182	579321	232	762886	282	897631	332	1082888
33	1055273	83	2641973	133	423349	183	582504	233	766886	283	900814	333	1086888
34	1087254	84	2673804	134	426532	184	585687	234	770886	284	903997	334	1090888
35	1119235	85	2705635	135	429715	185	588870	235	774886	285	907180	335	1094888
36	1151216	86	2737466	136	432898	186	592053	236	778886	286	910363	336	1098888
37	1183197	87	2769297	137	436081	187	595236	237	782886	287	913546	337	1102888
38	1215178	88	2801128	138	439264	188	598419	238	786886	288	916729	338	1106888
39	1247159	89	2832959	139	442447	189	601602	239	790886	289	919912	339	1110888
40	1279140	90	2864790	140	445630	190	604785	240	794886	290	923095	340	1114888
41	1311121	91	2896621	141	448813	191	607968	241	798886	291	926278	341	1118888
42	1343102	92	2928452	142	451996	192	611151	242	802886	292	929461	342	1122888
43	1375083	93	2960283	143	455179	193	614334	243	806886	293	932644	343	1126888
44	1407064	94	2992114	144	458362	194	617517	244	810886	294	935827	344	1130888
45	1439045	95	3023945	145	461545	195	620700	245	814886	295	939010	345	1134888
46	1471026	96	3055776	146	464728	196	623883	246	818886	296	942193	346	1138888
47	1503007	97	3087607	147	467911	197	627066	247	822886	297	945376	347	1142888
48	1534988	98	3119438	148	471094	198	630249	248	826886	298	948559	348	1146888
49	1566969	99	3151269	149	474277	199	633432	249	830886	299	951742	349	1150888
50	1598950	100	3183100	150	477460	200	636615	250	834886	300	954925	350	1154888

No. 35.

TABLE FOR REDUCING INCHES INTO POUNDS' WEIGHT AVOIRDUPOIS.

Pounds.	Inches.	Pounds.	Inches.	Pounds.	Inches.	Pounds.	Inches.	Pounds.	Inches.
1	27-7274	51	1414-0974	101	2800-4674	151	4186-8374	250	6931-85
2	55-4548	52	1441-8248	102	2828-1948	152	4214-5648	300	8318-22
3	83-1822	53	1469-5522	103	2855-9222	153	4242-2922	350	9704-59
4	110-9096	54	1497-2796	104	2883-6496	154	4270-0196	400	11090-96
5	138-6370	55	1525-0070	105	2911-3770	155	4297-7470	450	12477-33
6	166-3644	56	1552-7344	106	2939-1044	156	4325-4744	500	13863-70
7	194-0918	57	1580-4618	107	2966-8318	157	4353-2018	550	15250-07
8	221-8192	58	1608-1892	108	2994-5592	158	4380-9292	600	16636-44
9	249-5466	59	1635-9166	109	3022-2866	159	4408-6566	650	18022-81
10	277-274	60	1663-6440	110	3050-0140	160	4436-3840	700	19409-18
11	305-0014	61	1691-3714	111	3077-7414	161	4464-1114	750	20795-55
12	332-7288	62	1719-0988	112	3105-4688	162	4491-8388	800	22181-92
13	360-4562	63	1746-8262	113	3133-1962	163	4519-5662	850	23568-29
14	388-1836	64	1774-5536	114	3160-9236	164	4547-2936	900	24954-66
15	415-9110	65	1802-2810	115	3188-6510	165	4575-0210	950	26341-03
16	443-6384	66	1830-0084	116	3216-3784	166	4602-7484	1000	27727-40
17	471-3658	67	1857-7358	117	3244-1058	167	4630-4758	1100	30500-14
18	499-0932	68	1885-4632	118	3271-8332	168	4658-2032	1200	33272-88
19	526-8206	69	1913-1906	119	3299-5606	169	4685-9306	1300	36045-62
20	554-5480	70	1940-9180	120	3327-2880	170	4713-6580	1400	38818-36
21	582-2754	71	1968-6454	121	3355-0154	171	4741-3854	1500	41591-10
22	610-0028	72	1996-3728	122	3382-7428	172	4769-1128	1600	44363-84
23	637-7302	73	2024-1002	123	3410-4702	173	4796-8402	1700	47136-58
24	665-4576	74	2051-8276	124	3438-1976	174	4824-5676	1800	49909-32
25	693-1850	75	2079-5550	125	3465-9250	175	4852-2950	1900	52682-06
26	720-9124	76	2107-2824	126	3493-6524	176	4880-0224	2000	55454-80
27	748-6398	77	2135-0098	127	3521-3798	177	4907-7498	2100	58227-54
28	776-3672	78	2162-7372	128	3549-1072	178	4935-4772	2200	61090-28
29	804-0946	79	2190-4646	129	3576-8346	179	4963-2046	2300	63773-02
30	831-8220	80	2218-1920	130	3604-5620	180	4990-9320	2400	66545-76
31	859-5494	81	2245-9194	131	3632-2894	181	5018-6594	2500	69318-50
32	887-2768	82	2273-6468	132	3660-0168	182	5046-3868	2600	72091-24
33	915-0042	83	2301-3742	133	3687-7442	183	5074-1142	2700	74863-98
34	942-7316	84	2329-1016	134	3715-4716	184	5101-8416	2800	77636-72
35	970-4590	85	2356-8290	135	3743-1990	185	5129-5690	2900	80409-46
36	998-1864	86	2384-5564	136	3770-9264	186	5157-2964	3000	83182-20
37	1025-9138	87	2412-2838	137	3798-6538	187	5185-0238	3100	85954-94
38	1053-6412	88	2440-0112	138	3826-3812	188	5212-7512	3200	88727-68
39	1081-3686	89	2467-7386	139	3854-1086	189	5240-4786	3300	91500-42
40	1109-0960	90	2495-4660	140	3881-8360	190	5268-2060	3400	94273-16
41	1136-8234	91	2523-1934	141	3909-5634	191	5295-9334	3500	97045-90
42	1164-5508	92	2550-9208	142	3937-2908	192	5323-6608	3600	99818-64
43	1192-2782	93	2578-6482	143	3965-0182	193	5351-3882	3700	102591-38
44	1220-0056	94	2606-3756	144	3992-7456	194	5379-1156	3800	105364-12
45	1247-7330	95	2634-1030	145	4020-4730	195	5406-8430	3900	108136-86
46	1275-4604	96	2661-8304	146	4048-2004	196	5434-5704	4000	110909-60
47	1303-1878	97	2689-5578	147	4075-9278	197	5462-2978	5000	138637-00
48	1330-9152	98	2717-2852	148	4103-6552	198	5490-0252	6000	166364-40
49	1358-6426	99	2745-0126	149	4131-3826	199	5517-7526	7000	194091-80
50	1386-3700	100	2772-7400	150	4159-1100	200	5545-4800	10000	277274-00

No. 36.

TABLE FOR REDUCING INCHES INTO GALLONS.

	Gallons.	Inches.	Gallons.	Inches.	Gallons.	Inches.	Gallons.	Inches.	
1	277-274	51	14140-974	101	28004-674	151	41868-374	250	69318-5
2	554-548	52	14418-248	102	28281-948	152	42145-648	300	83182-2
3	831-822	53	14695-522	103	28559-222	153	42422-922	350	97045-9
4	1109-096	54	14972-796	104	28836-496	154	42700-196	400	110909-6
5	1386-370	55	15250-070	105	29113-770	155	42977-470	450	124773-3
6	1663-644	56	15527-344	106	29391-044	156	43254-744	500	138637-0
7	1940-918	57	15804-618	107	29668-318	157	43532-018	550	152500-7
8	2218-192	58	16081-892	108	29945-592	158	43809-292	600	166364-4
9	2495-466	59	16359-166	109	30222-866	159	44086-566	650	180228-1
10	2772-74	60	16636-440	110	30500-140	160	44363-840	700	194091-8
11	3050-014	61	16913-714	111	30777-414	161	44641-114	750	207955-5
12	3327-288	62	17190-988	112	31054-688	162	44918-388	800	221819-2
13	3604-562	63	17468-262	113	31331-962	163	45195-662	850	235682-9
14	3881-836	64	17745-536	114	31609-236	164	45472-936	900	249546-6
15	4159-110	65	18022-810	115	31886-510	165	45750-210	950	263410-3
16	4436-384	66	18300-084	116	32163-784	166	46027-484	1000	277274-0
17	4713-658	67	18577-358	117	32441-058	167	46304-758	1100	305001-4
18	4990-932	68	18854-632	118	32718-332	168	46582-032	1200	332728-8
19	5268-206	69	19131-906	119	32995-606	169	46859-306	1300	360456-2
20	5545-480	70	19409-180	120	33272-880	170	47136-580	1400	388183-6
21	5822-754	71	19686-454	121	33550-154	171	47413-854	1500	415911-0
22	6100-028	72	19963-728	122	33827-428	172	47691-128	1600	443638-4
23	6377-302	73	20241-002	123	34104-702	173	47968-402	1700	471365-8
24	6654-576	74	20518-276	124	34381-976	174	48245-676	1800	499093-2
25	6931-850	75	20795-550	125	34659-250	175	48522-950	1900	526820-6
26	7209-124	76	21072-824	126	34936-524	176	48800-224	2000	554548-0
27	7486-398	77	21350-098	127	35213-798	177	49077-498	2100	582275-4
28	7763-672	78	21627-372	128	35491-072	178	49354-772	2200	610002-8
29	8040-946	79	21904-646	129	35768-346	179	49632-046	2300	637730-2
30	8318-220	80	22181-920	130	36045-620	180	49909-320	2400	665457-6
31	8595-494	81	22459-194	131	36322-894	181	50186-594	2500	693185-0
32	8872-768	82	22736-468	132	36600-168	182	50463-868	2600	720912-4
33	9150-042	83	23013-742	133	36877-442	183	50741-142	2700	748639-8
34	9427-316	84	23291-016	134	37154-716	184	51018-416	2800	776367-2
35	9704-590	85	23568-290	135	37431-990	185	51295-690	2900	804094-6
36	9981-864	86	23845-564	136	37709-264	186	51572-964	3000	831822-0
37	10259-138	87	24122-838	137	37986-538	187	51850-238	3100	859549-4
38	10536-412	88	24400-112	138	38263-812	188	52127-512	3200	887276-8
39	10813-686	89	24677-386	139	38541-086	189	52404-786	3300	915004-2
40	11090-960	90	24954-660	140	38818-360	190	52682-060	3400	942731-6
41	11368-234	91	25231-934	141	39095-634	191	52959-334	3500	970459-0
42	11645-508	92	25509-208	142	39372-908	192	53236-608	3600	998186-4
43	11922-782	93	25786-482	143	39650-182	193	53513-882	3700	1025913-8
44	12200-056	94	26063-756	144	39927-456	194	53791-156	3800	1053641-2
45	12477-330	95	26341-030	145	40204-730	195	54068-430	3900	1081368-6
46	12754-604	96	26618-304	146	40482-004	196	54345-704	4000	1109096-0
47	13031-878	97	26895-578	147	40759-278	197	54622-978	5000	1386370-0
48	13309-152	98	27172-852	148	41036-552	198	54900-252	6000	1663644-0
49	13586-426	99	27450-126	149	41313-826	199	55177-526	7000	1940918-0
50	13863-700	100	27727-400	150	41591-100	200	55454-800	10000	2772740-0

TABLE OF THE AREAS OF SEMI-SQUARES IN IMPERIAL GALLONS.—continued.

Sides in inches.	0	1	2	3	4	5	6	7	8	9
51	4.6903	4.7087	4.7279	4.7456	4.7642	4.7827	4.8013	4.8199	4.8386	4.8573
52	4.8760	4.8948	4.9136	4.9325	4.9513	4.9703	4.9892	5.0082	5.0272	5.0463
53	5.0654	5.0845	5.1037	5.1229	5.1421	5.1614	5.1807	5.2001	5.2195	5.2389
54	5.2583	5.2778	5.2974	5.3169	5.3365	5.3562	5.3758	5.3955	5.4153	5.4351
55	5.4549	5.4747	5.4946	5.5146	5.5345	5.5545	5.5746	5.5946	5.6147	5.6349
56	5.6551	5.6753	5.6955	5.7158	5.7361	5.7565	5.7769	5.7973	5.8178	5.8383
57	5.8588	5.8794	5.9000	5.9207	5.9413	5.9621	5.9828	6.0036	6.0244	6.0453
58	6.0662	6.0871	6.1081	6.1291	6.1502	6.1712	6.1924	6.2135	6.2347	6.2559
59	6.2772	6.2985	6.3198	6.3412	6.3626	6.3840	6.4055	6.4270	6.4486	6.4702
60	6.4918	6.5134	6.5351	6.5569	6.5786	6.6004	6.6223	6.6441	6.6660	6.6880
61	6.7100	6.7320	6.7540	6.7761	6.7983	6.8204	6.8426	6.8649	6.8871	6.9094
62	6.9318	6.9542	6.9766	6.9990	7.0215	7.0440	7.0666	7.0892	7.1118	7.1345
63	7.1572	7.1799	7.2027	7.2255	7.2484	7.2712	7.2942	7.3171	7.3401	7.3631
64	7.3862	7.4093	7.4324	7.4556	7.4788	7.5021	7.5253	7.5487	7.5720	7.5954
65	7.6188	7.6423	7.6658	7.6893	7.7129	7.7365	7.7601	7.7838	7.8075	7.8313
66	7.8550	7.8789	7.9027	7.9266	7.9505	7.9745	7.9985	8.0226	8.0466	8.0707
67	8.0949	8.1191	8.1433	8.1675	8.1918	8.2162	8.2405	8.2649	8.2893	8.3138
68	8.3383	8.3629	8.3874	8.4121	8.4367	8.4614	8.4861	8.5109	8.5357	8.5605
69	8.5854	8.6103	8.6352	8.6602	8.6852	8.7102	8.7353	8.7604	8.7856	8.8108
70	8.8360	8.8613	8.8866	8.9119	8.9373	8.9627	8.9881	9.0136	9.0391	9.0647
71	9.0903	9.1159	9.1416	9.1673	9.1930	9.2188	9.2446	9.2704	9.2963	9.3222
72	9.3482	9.3741	9.4002	9.4262	9.4523	9.4784	9.5046	9.5308	9.5570	9.5833
73	9.6096	9.6360	9.6624	9.6888	9.7152	9.7417	9.7682	9.7948	9.8214	9.8480
74	9.8747	9.9014	9.9282	9.9549	9.9818	10.0086	10.0355	10.0624	10.0894	10.1164
75	10.1434	10.1705	10.1976	10.2247	10.2519	10.2791	10.3063	10.3336	10.3609	10.3883
76	10.4157	10.4431	10.4706	10.4981	10.5256	10.5532	10.5808	10.6084	10.6361	10.6638
77	10.6916	10.7194	10.7472	10.7751	10.8030	10.8309	10.8589	10.8869	10.9149	10.9430
78	10.9711	10.9992	11.0274	11.0557	11.0839	11.1122	11.1405	11.1689	11.1972	11.2257
79	11.2542	11.2827	11.3113	11.3398	11.3685	11.3971	11.4258	11.4545	11.4833	11.5121
80	11.5409	11.5698	11.5987	11.6276	11.6566	11.6856	11.7147	11.7438	11.7729	11.8021
81	11.8313	11.8605	11.8898	11.9191	11.9484	11.9778	12.0072	12.0366	12.0661	12.0955
82	12.1252	12.1548	12.1844	12.2141	12.2438	12.2735	12.3033	12.3331	12.3629	12.3928
83	12.4227	12.4527	12.4827	12.5127	12.5428	12.5729	12.6030	12.6332	12.6634	12.6936
84	12.7239	12.7542	12.7845	12.8149	12.8453	12.8758	12.9063	12.9368	12.9674	12.9980
85	13.0286	13.0593	13.0900	13.1208	13.1515	13.1824	13.2132	13.2441	13.2750	13.3060
86	13.3370	13.3680	13.3991	13.4302	13.4613	13.4925	13.5237	13.5550	13.5863	13.6176
87	13.6490	13.6803	13.7118	13.7432	13.7747	13.8063	13.8379	13.8695	13.9011	13.9328
88	13.9645	13.9963	14.0281	14.0599	14.0918	14.1237	14.1556	14.1876	14.2196	14.2516
89	14.2837	14.3158	14.3480	14.3802	14.4124	14.4446	14.4769	14.5093	14.5416	14.5740
90	14.6065	14.6390	14.6715	14.7040	14.7366	14.7692	14.8019	14.8346	14.8673	14.9001
91	14.9329	14.9657	14.9986	15.0315	15.0644	15.0974	15.1304	15.1635	15.1966	15.2297
92	15.2629	15.2961	15.3293	15.3626	15.3959	15.4292	15.4626	15.4960	15.5295	15.5630
93	15.5965	15.6300	15.6636	15.6973	15.7309	15.7646	15.7984	15.8322	15.8660	15.8998
94	15.9337	15.9676	16.0016	16.0356	16.0696	16.1037	16.1378	16.1719	16.2061	16.2403
95	16.2745	16.3088	16.3431	16.3775	16.4119	16.4463	16.4807	16.5152	16.5498	16.5843
96	16.6189	16.6536	16.6883	16.7230	16.7577	16.7925	16.8273	16.8622	16.8971	16.9320
97	16.9670	17.0020	17.0370	17.0721	17.1072	17.1423	17.1775	17.2127	17.2480	17.2833
98	17.3186	17.3540	17.3894	17.4248	17.4603	17.4958	17.5313	17.5669	17.6025	17.6382
99	17.6739	17.7096	17.7453	17.7811	17.8170	17.8528	17.8887	17.9247	17.9606	17.9967
100	18.0327	18.0688	18.1049	18.1411	18.1773	18.2135	18.2497	18.2860	18.3224	18.3588

TABLE OF THE AREAS OF SEMI-SQUARES IN IMPERIAL GALLONS—continued.

Sides in inches.	Area.	Sides in inches.	Area.	Sides in inches.	Area.	Sides in inches.	Area.	Sides in inches.	Area.	Sides in inches.	Area.
101	18-3952	151	41-1164	201	79-8539	251	113-6078	301	163-3781	351	222-1647
102	18-7612	152	41-6628	202	79-5806	252	114-5149	302	164-4655	352	223-4324
103	19-1309	153	42-2128	203	74-3110	253	115-4255	303	165-5565	353	224-7037
104	19-5042	154	42-7654	204	75-0449	254	116-3398	304	166-6510	354	225-9786
105	19-8811	155	43-3236	205	75-7824	255	117-2577	305	167-7492	355	227-2572
106	20-2615	156	43-8844	206	76-5236	256	118-1791	306	168-8510	356	228-5393
107	20-6456	157	44-1488	207	77-2683	257	119-1042	307	169-9564	357	229-8250
108	21-0333	158	45-0168	208	78-0167	258	120-0329	308	171-0654	358	231-1143
109	21-4247	159	45-5885	209	78-7687	259	120-9652	309	172-1781	359	232-4073
110	21-8196	160	46-1637	210	79-5242	260	121-9011	310	173-2943	360	233-7038
111	22-2181	161	46-7426	211	80-2834	261	122-8406	311	174-4141	361	235-0040
112	22-6202	162	47-3250	212	81-0462	262	123-7837	312	175-5376	362	236-3078
113	23-0260	163	47-9111	213	81-8126	263	124-7304	313	176-6646	363	237-6151
114	23-4353	164	48-5008	214	82-5826	264	125-6807	314	177-7952	364	238-9261
115	23-8483	165	49-0940	215	83-3562	265	126-6347	315	178-9295	365	240-2407
116	24-2648	166	49-6909	216	84-1334	266	127-5922	316	180-0674	366	241-5589
117	24-6850	167	50-2914	217	84-9142	267	128-5533	317	181-2088	367	242-8807
118	25-1087	168	50-8955	218	85-6986	268	129-5181	318	182-3539	368	244-2061
119	25-5361	169	51-5032	219	86-4867	269	130-4864	319	183-5026	369	245-5351
120	25-9671	170	52-1145	220	87-2783	270	131-4584	320	184-6549	370	246-8677
121	26-4017	171	52-7294	221	88-0735	271	132-4340	321	185-8108	371	248-2039
122	26-8399	172	53-3480	222	88-8724	272	133-4132	322	186-9703	372	249-5438
123	27-2817	173	53-9701	223	89-6748	273	134-3959	323	188-1334	373	250-8872
124	27-7271	174	54-5958	224	90-4809	274	135-3823	324	189-3001	374	252-2343
125	28-1761	175	55-2252	225	91-2906	275	136-3723	325	190-4704	375	253-5849
126	28-6287	176	55-8581	226	92-1038	276	137-3659	326	191-6444	376	254-9392
127	29-0849	177	56-4947	227	92-9207	277	138-3631	327	192-8219	377	256-2970
128	29-5448	178	57-1348	228	93-7412	278	139-3640	328	194-0030	378	257-6585
129	30-0082	179	57-7786	229	94-5653	279	140-3684	329	195-1878	379	259-0235
130	30-4753	180	58-4260	230	95-3930	280	141-3764	330	196-3761	380	260-3922
131	30-9459	181	59-0769	231	96-2243	281	142-3880	331	197-5681	381	261-7645
132	31-4202	182	59-7315	232	97-0592	282	143-4033	332	198-7657	382	263-1404
133	31-8981	183	60-3897	233	97-8977	283	144-4221	333	199-9629	383	264-5199
134	32-3795	184	61-0515	234	98-7399	284	145-4446	334	201-1656	384	265-9030
135	32-8646	185	61-7169	235	99-5856	285	146-4706	335	202-3720	385	267-2898
136	33-3533	186	62-3859	236	100-4349	286	147-5003	336	203-5820	386	268-6801
137	33-8456	187	63-0586	237	101-2879	287	148-5336	337	204-7956	387	270-0740
138	34-3415	188	63-7348	238	102-1444	288	149-5705	338	206-0128	388	271-4715
139	34-8410	189	64-4146	239	103-0046	289	150-6109	339	207-2336	389	272-8727
140	35-3441	190	65-0981	240	103-8684	290	151-6550	340	208-4581	390	274-2774
141	35-8508	191	65-7851	241	104-7257	291	152-7027	341	209-6861	391	275-6858
142	36-3611	192	66-4758	242	105-6057	292	153-7540	342	210-9177	392	277-0977
143	36-8751	193	67-1700	243	106-4813	293	154-8090	343	212-1530	393	278-5133
144	37-3926	194	67-8679	244	107-3593	294	155-8675	344	213-3918	394	279-9325
145	37-9138	195	68-5694	245	108-2413	295	156-9296	345	214-6343	395	281-3553
146	38-4385	196	69-2744	246	109-1267	296	157-9953	346	215-8803	396	282-7817
147	38-9669	197	69-9831	247	110-0157	297	159-0647	347	217-1300	397	284-2116
148	39-4988	198	70-6954	248	110-9083	298	160-1376	348	218-3833	398	285-6452
149	40-0344	199	71-4113	249	111-8046	299	161-2142	349	219-6401	399	287-0825
150	40-5736	200	72-1308	250	112-7044	300	162-2943	350	220-9006	400	288-5233

TABLE OF THE AREAS OF SEMI-SQUARES IN IMPERIAL GALLONS.—continued.

Sides in inches.	Area.	Sides in inches.	Area.	Sides in inches.	Area.	Sides in inches.	Area.	Sides in inches.	Area.	Sides in inches.	Area.
401	289-0677	451	366-7870	501	452-6227	551	547-4747	601	651-3431	651	764-2278
402	291-4157	452	368-4154	502	454-4314	552	549-4637	602	653-5124	652	766-5772
403	292-8673	453	370-0473	503	456-2436	553	551-4563	603	655-6854	653	768-9307
404	294-3226	454	371-6829	504	458-0595	554	553-4525	604	657-8610	654	771-2876
405	295-7814	455	373-3221	505	459-8790	555	555-4524	605	660-0421	655	773-6481
406	297-2439	456	374-9648	506	461-7021	556	557-4558	606	662-2258	656	776-0122
407	298-7099	457	376-6112	507	463-5289	557	559-4628	607	664-4132	657	778-3799
408	300-1796	458	378-2612	508	465-3592	558	561-4735	608	666-6042	658	780-7512
409	301-6529	459	379-9148	509	467-1931	559	563-4877	609	668-7987	659	783-1261
410	303-1298	460	381-5730	510	469-0306	560	565-5056	610	670-9969	660	785-5046
411	304-6102	461	383-2328	511	470-8718	561	567-5271	611	673-1987	661	787-8867
412	306-0943	462	384-8972	512	472-7165	562	569-5521	612	675-4041	662	790-2724
413	307-5820	463	386-5653	513	474-5649	563	571-5808	613	677-6131	663	792-6618
414	309-0733	464	388-2369	514	476-4168	564	573-6131	614	679-8257	664	795-0547
415	310-5682	465	389-9121	515	478-2724	565	575-6490	615	682-0420	665	797-4513
416	312-0668	466	391-5910	516	480-1316	566	577-6885	616	684-2618	666	799-8514
417	313-5699	467	393-2734	517	481-9943	567	579-7316	617	686-4852	667	802-2552
418	315-0746	468	394-9595	518	483-8607	568	581-7783	618	688-7132	668	804-6625
419	316-5840	469	396-6492	519	485-7307	569	583-8286	619	690-9429	669	807-0725
420	318-0969	470	398-3424	520	487-6043	570	585-8826	620	693-1771	670	809-4881
421	319-6135	471	400-0393	521	489-4815	571	587-9401	621	695-4150	671	811-9063
422	321-1336	472	401-7398	522	491-3623	572	590-0012	622	697-6565	672	814-3281
423	322-6574	473	403-4439	523	493-2468	573	592-0660	623	699-9015	673	816-7535
424	324-1847	474	405-1516	524	495-1348	574	594-1343	624	702-1502	674	819-1825
425	325-7157	475	406-8629	525	497-0264	575	596-2063	625	704-4025	675	821-6151
426	327-2503	476	408-5778	526	498-9216	576	598-2818	626	706-6584	676	824-0513
427	328-7885	477	410-2963	527	500-8205	577	600-3610	627	708-9179	677	826-4911
428	330-3303	478	412-0184	528	502-7229	578	602-4438	628	711-1810	678	828-9346
429	327-8757	479	413-7442	529	504-6290	579	604-5302	629	713-4477	679	831-3816
430	333-4247	480	415-4735	530	506-5387	580	606-6202	630	715-7180	680	833-8322
431	334-9773	481	417-2064	531	508-4519	581	608-7138	631	717-9920	681	836-2865
432	336-5335	482	418-9430	532	510-3688	582	610-8110	632	720-2695	682	838-7443
433	338-0934	483	420-6832	533	512-2893	583	612-9118	633	722-5506	683	841-2058
434	339-6568	484	422-4269	534	514-2134	584	615-0162	634	724-8354	684	843-6709
435	341-2238	485	424-1743	535	516-1411	585	617-1242	635	727-1237	685	846-1396
436	342-7945	486	425-9253	536	518-0724	586	619-2358	636	729-4157	686	848-6118
437	344-3687	487	427-6798	537	520-0073	587	621-3511	637	731-7112	687	851-0877
438	345-9466	488	429-4380	538	521-9458	588	623-4699	638	734-0104	688	853-5672
439	347-5281	489	431-1998	539	523-8879	589	625-5924	639	736-3132	689	856-0503
440	349-1132	490	432-9652	540	525-8337	590	627-7184	640	738-6196	690	858-5370
441	350-7018	491	434-7342	541	527-7830	591	629-8481	641	740-9295	691	861-0273
442	352-2941	492	436-5068	542	529-7359	592	631-9814	642	743-2431	692	863-5213
443	353-8900	493	438-2831	543	531-6925	593	634-1182	643	745-5603	693	866-0188
444	355-4895	494	440-0629	544	533-6526	594	636-2587	644	747-8812	694	868-5199
445	357-0926	495	441-8463	545	535-6164	595	638-4028	645	750-2056	695	871-0247
446	358-6993	496	443-6334	546	537-5838	596	640-5505	646	752-5336	696	873-5330
447	360-3097	497	445-4240	547	539-5547	597	642-7018	647	754-8652	697	876-0450
448	361-9236	498	447-2183	548	541-5293	598	644-8567	648	757-2005	698	878-5606
449	363-5411	499	449-0161	549	543-5075	599	647-0152	649	759-5393	699	881-0797
450	365-1623	500	450-8176	550	545-4893	600	649-1773	650	761-8817	700	883-6025

TABLE OF THE AREAS OF SEMI-SQUARES IN IMPERIAL GALLONS.—continued.

Sides in inches.	Area.	Sides in inches.	Area.	Sides in inches.	Area.	Sides in inches.	Area.	Sides in inches.	Area.
701	886-1289	721	937-4139	741	990-1415	761	1044-3118	781	1099-9246
702	888-6589	722	940-0160	742	992-8158	762	1047-0581	782	1103-7431
703	891-1925	723	942-6217	743	995-4935	763	1049-8081	783	1105-5653
704	893-7297	724	945-2311	744	998-1751	764	1052-5617	784	1108-3910
705	896-2705	725	947-8440	745	1000-8602	765	1055-3189	785	1111-2203
706	898-8149	726	950-4606	746	1003-5488	766	1058-0797	786	1114-0532
707	901-3629	727	953-0807	747	1006-2411	767	1060-8441	787	1116-8895
708	903-9145	728	955-7045	748	1008-9370	768	1063-6122	788	1119-7299
709	906-4698	729	958-3318	749	1011-6365	769	1066-3838	789	1122-5737
710	909-0286	730	960-9628	750	1014-3396	770	1069-1590	790	1125-4211
711	911-5911	731	963-5974	751	1017-0463	771	1071-9379	791	1128-2720
712	914-1571	732	966-2356	752	1019-7566	772	1074-7203	792	1131-1266
713	916-7268	733	968-8774	753	1022-4706	773	1077-5064	793	1133-9845
714	919-3000	734	971-5228	754	1025-1881	774	1080-2960	794	1136-8466
715	921-8769	735	974-1718	755	1027-9092	775	1083-0893	795	1139-7120
716	924-4574	736	976-8244	756	1030-6340	776	1085-8862	796	1142-5810
717	927-0415	737	979-4806	757	1033-3623	777	1088-6866	797	1145-4536
718	929-6292	738	982-1404	758	1036-0943	778	1091-4907	798	1148-3298
719	932-2205	739	984-8038	759	1038-8298	779	1094-2984	799	1151-2096
720	934-8154	740	987-4709	760	1041-5690	780	1097-1097	800	1154-0931

No. 39.

TABLE OF THE AREAS OF RECTANGULAR FIGURES IN BUSHELS.

	150.	151.	152.	153.	154.	155.	156.	157.	158.	159.
100	6-7622	6-9073	6-8524	6-8975	6-9426	6-9877	7-0327	7-0778	7-1229	7-1680
101	6-8299	6-8764	6-9209	6-9665	7-0120	7-0575	7-1031	7-1486	7-1941	7-2397
102	6-8975	6-9434	6-9886	7-0354	7-0814	7-1274	7-1734	7-2194	7-2653	7-3114
103	6-9651	7-0115	7-0580	7-1044	7-1509	7-1973	7-2437	7-2902	7-3366	7-3830
104	7-0328	7-0796	7-1265	7-1734	7-2203	7-2672	7-3141	7-3610	7-4078	7-4547
105	7-1004	7-1477	7-1950	7-2424	7-2897	7-3371	7-3844	7-4317	7-4790	7-5264
106	7-1680	7-2158	7-2636	7-3113	7-3591	7-4069	7-4547	7-5025	7-5502	7-5981
107	7-2356	7-2830	7-3304	7-3780	7-4256	7-4732	7-5208	7-5684	7-6160	7-6637
108	7-3032	7-3519	7-4006	7-4493	7-4980	7-5467	7-5954	7-6440	7-6927	7-7414
109	7-3708	7-4200	7-4691	7-5183	7-5674	7-6166	7-6657	7-7148	7-7639	7-8131
110	7-4385	7-4881	7-5377	7-5873	7-6368	7-6864	7-7360	7-7856	7-8351	7-8848
111	7-5061	7-5561	7-6062	7-6562	7-7062	7-7563	7-8063	7-8564	7-9063	7-9565
112	7-5737	7-6242	7-6747	7-7252	7-7757	7-8262	7-8767	7-9272	7-9776	8-0282
113	7-6413	7-6923	7-7432	7-7942	7-8451	7-8961	7-9470	7-9979	8-0488	8-0998
114	7-7090	7-7604	7-8118	7-8632	7-9145	7-9660	8-0173	8-0687	8-1200	8-1715
115	7-7766	7-8285	7-8803	7-9321	7-9839	8-0358	8-0876	8-1395	8-1913	8-2432
116	7-8442	7-8965	7-9488	8-0011	8-0533	8-1057	8-1580	8-2103	8-2625	8-3149
117	7-9118	7-9646	8-0173	8-0701	8-1228	8-1756	8-2283	8-2810	8-3337	8-3866
118	7-9794	8-0327	8-0859	8-1391	8-1922	8-2455	8-2986	8-3518	8-4050	8-4582
119	8-0471	8-1008	8-1544	8-2080	8-2616	8-3153	8-3689	8-4226	8-4762	8-5299
120	8-1147	8-1688	8-2229	8-2770	8-3310	8-3852	8-4393	8-4934	8-5474	8-6016
121	8-1823	8-2369	8-2914	8-3460	8-4005	8-4551	8-5096	8-5641	8-6187	8-6733
122	8-2499	8-3049	8-3600	8-4149	8-4699	8-5250	8-5799	8-6349	8-6899	8-7450
123	8-3176	8-3730	8-4286	8-4839	8-5393	8-5949	8-6502	8-7057	8-7611	8-8166
124	8-3852	8-4411	8-4970	8-5529	8-6088	8-6648	8-7206	8-7765	8-8324	8-8883
125	8-4528	8-5092	8-5655	8-6219	8-6782	8-7346	8-7909	8-8473	8-9036	8-9600

No. 40.

TABLE OF THE AREAS OF CIRCLES IN IMPERIAL GALLONS.

Diameters in Inches.	0	1	2	3	4	5	6	7	8	9
1	0028	0034	0040	0047	0055	0063	0072	0081	0091	0102
2	0113	0124	0137	0149	0163	0177	0191	0206	0222	0238
3	0254	0272	0290	0308	0327	0346	0367	0387	0409	0430
4	0453	0476	0499	0523	0548	0573	0599	0625	0652	0680
5	0708	0736	0765	0795	0825	0856	0888	0920	0952	0986
6	1019	1053	1088	1124	1160	1196	1233	1271	1309	1348
7	1387	1427	1468	1509	1551	1593	1636	1679	1723	1767
8	1812	1858	1904	1951	1998	2046	2094	2143	2193	2243
9	2294	2345	2397	2449	2502	2556	2610	2665	2720	2776
10	2832	2889	2947	3005	3063	3122	3182	3243	3303	3363
11	3427	3490	3553	3616	3681	3746	3811	3877	3944	4011
12	4078	4147	4215	4285	4355	4425	4496	4568	4640	4713
13	4787	4860	4935	5010	5086	5162	5239	5316	5394	5472
14	5551	5631	5711	5792	5873	5955	6037	6120	6204	6288
15	6373	6458	6544	6630	6717	6805	6893	6982	7071	7161
16	7251	7342	7433	7525	7618	7711	7805	7899	7994	8090
17	8186	8282	8379	8477	8575	8674	8774	8874	8974	9075
18	9177	9279	9382	9485	9589	9694	9799	9905	10011	10118
19	10225	10333	10441	10551	10660	10770	10881	10992	11104	11217
20	11330	11443	11558	11672	11788	11903	12020	12137	12254	12372
21	12491	12610	12730	12851	12972	13093	13215	13338	13461	13585
22	13709	13834	13960	14086	14212	14339	14467	14595	14724	14854
23	14984	15114	15245	15377	15510	15642	15776	15910	16044	16179
24	16315	16451	16588	16726	16863	17002	17141	17281	17421	17562
25	17703	17845	17987	18131	18274	18418	18563	18708	18854	19001
26	19148	19295	19443	19592	19741	19891	20042	20193	20344	20496
27	20640	20802	20966	21130	21295	21461	21627	21794	21961	22129
28	22307	22476	22645	22815	22986	23157	23329	23501	23674	23847
29	23821	23986	24151	24317	24483	24650	24817	24985	25154	25323
30	25493	25663	25834	26005	26177	26349	26522	26696	26870	27045
31	27221	27396	27573	27750	27928	28106	28284	28464	28644	28824
32	29005	29187	29369	29551	29733	29915	30103	30288	30473	30660
33	30847	31033	31221	31410	31599	31788	31978	32169	32360	32552
34	32744	32937	33130	33324	33519	33714	33910	34106	34303	34500
35	34698	34897	35096	35296	35496	35697	35898	36100	36303	36506
36	36710	36914	37119	37324	37530	37736	37943	38151	38359	38568
37	38777	38987	39198	39409	39620	39833	40045	40259	40473	40687
38	40902	41117	41334	41550	41767	41985	42204	42423	42643	42862
39	43083	43304	43526	43748	43971	44195	44419	44643	44869	45094
40	45321	45548	45775	46003	46232	46461	46690	46921	47152	47383
41	47615	47848	48081	48314	48549	48783	49019	49255	49491	49728
42	49966	50204	50443	50682	50922	51163	51405	51645	51888	52130
43	52374	52618	52862	53107	53353	53599	53846	54093	54341	54589
44	54838	55088	55338	55588	55840	56091	56344	56597	56850	57104
45	57359	57614	57870	58126	58383	58641	58899	59157	59417	59676
46	59937	60198	60459	60721	60984	61247	61510	61775	62040	62305
47	62571	62838	63105	63372	63641	63909	64179	64449	64719	64990
48	65262	65534	65807	66080	66354	66630	66904	67179	67458	67732
49	68010	68287	68566	68845	69124	69405	69685	69967	70248	70531
50	70814	71097	71381	71666	71951	72237	72524	72810	73098	73386

TABLE OF THE AREAS OF CIRCLES IN IMPERIAL GALLONS.—continued.

Diameters in Inches.	0	1	2	3	4	5	6	7	8	9
51	7.3675	7.3964	7.4254	7.4544	7.4835	7.5126	7.5418	7.5711	7.6004	7.6298
52	7.6592	7.6887	7.7183	7.7479	7.7775	7.8072	7.8370	7.8668	7.8967	7.9266
53	7.9566	7.9867	8.0168	8.0470	8.0772	8.1075	8.1378	8.1682	8.1987	8.2292
54	8.2597	8.2903	8.3210	8.3518	8.3825	8.4134	8.4443	8.4753	8.5063	8.5373
55	8.5683	8.5997	8.6309	8.6622	8.6936	8.7250	8.7564	8.7880	8.8196	8.8512
56	8.8829	8.9146	8.9465	8.9783	9.0102	9.0422	9.0743	9.1064	9.1385	9.1707
57	9.2030	9.2353	9.2677	9.3001	9.3326	9.3651	9.3977	9.4304	9.4631	9.4959
58	9.5287	9.5616	9.5945	9.6275	9.6606	9.6937	9.7269	9.7601	9.7934	9.8267
59	9.8601	9.8936	9.9271	9.9607	9.9943	10.0280	10.0617	10.0955	10.1293	10.1632
60	10.1972	10.2312	10.2653	10.2994	10.3335	10.3679	10.4022	10.4365	10.4709	10.5054
61	10.5399	10.5745	10.6092	10.6439	10.6786	10.7134	10.7483	10.7832	10.8182	10.8533
62	10.8884	10.9235	10.9587	10.9940	11.0293	11.0647	11.1001	11.1356	11.1712	11.2068
63	11.2424	11.2781	11.3139	11.3497	11.3856	11.4216	11.4576	11.4936	11.5298	11.5659
64	11.6022	11.6384	11.6748	11.7112	11.7476	11.7842	11.8207	11.8573	11.8940	11.9308
65	11.9676	12.0044	12.0413	12.0783	12.1153	12.1524	12.1895	12.2267	12.2640	12.3013
66	12.3386	12.3760	12.4135	12.4511	12.4886	12.5263	12.5640	12.6017	12.6396	12.6774
67	12.7154	12.7533	12.7914	12.8295	12.8676	12.9058	12.9441	12.9824	13.0208	13.0593
68	13.0978	13.1363	13.1749	13.2136	13.2523	13.2911	13.3299	13.3688	13.4078	13.4468
69	13.4858	13.5249	13.5641	13.6033	13.6426	13.6820	13.7214	13.7608	13.8003	13.8399
70	13.8795	13.9192	13.9590	13.9988	14.0386	14.0785	14.1185	14.1585	14.1986	14.2387
71	14.2789	14.3192	14.3595	14.3999	14.4403	14.4808	14.5213	14.5619	14.6025	14.6432
72	14.6840	14.7248	14.7657	14.8066	14.8476	14.8886	14.9297	14.9709	15.0121	15.0534
73	15.0947	15.1361	15.1775	15.2190	15.2606	15.3022	15.3439	15.3856	15.4274	15.4692
74	15.5111	15.5531	15.5951	15.6371	15.6792	15.7214	15.7637	15.8059	15.8483	15.8907
75	15.9339	15.9757	16.0182	16.0609	16.1036	16.1463	16.1891	16.2320	16.2749	16.3179
76	16.3609	16.4040	16.4471	16.4903	16.5336	16.5769	16.6202	16.6637	16.7071	16.7507
77	16.7943	16.8379	16.8816	16.9254	16.9692	17.0131	17.0570	17.1010	17.1450	17.1891
78	17.2333	17.2775	17.3218	17.3661	17.4105	17.4550	17.4995	17.5440	17.5886	17.6333
79	17.6780	17.7228	17.7676	17.8125	17.8575	17.9025	17.9476	17.9927	18.0379	18.0831
80	18.1284	18.1738	18.2192	18.2646	18.3101	18.3557	18.4013	18.4470	18.4928	18.5386
81	18.5844	18.6304	18.6763	18.7224	18.7684	18.8146	18.8608	18.9070	18.9534	18.9997
82	19.0462	19.0926	19.1392	19.1858	19.2324	19.2791	19.3259	19.3727	19.4196	19.4665
83	19.5135	19.5606	19.6077	19.6548	19.7021	19.7493	19.7967	19.8441	19.8915	19.9390
84	19.9866	20.0342	20.0819	20.1296	20.1774	20.2252	20.2731	20.3211	20.3691	20.4171
85	20.4653	20.5135	20.5617	20.6100	20.6583	20.7067	20.7552	20.8037	20.8523	20.9009
86	20.9496	20.9984	21.0472	21.0961	21.1450	21.1940	21.2430	21.2921	21.3412	21.3904
87	21.4397	21.4892	21.5384	21.5878	21.6373	21.6868	21.7364	21.7861	21.8358	21.8856
88	21.9354	21.9853	22.0353	22.0853	22.1352	22.1852	22.2355	22.2857	22.3360	22.3863
89	22.4367	22.4872	22.5377	22.5883	22.6389	22.6895	22.7403	22.7911	22.8419	22.8928
90	22.9438	22.9948	23.0459	23.0970	23.1482	23.1994	23.2507	23.3021	23.3535	23.4049
91	23.4565	23.5080	23.5597	23.6114	23.6631	23.7149	23.7668	23.8187	23.8707	23.9227
92	23.9748	24.0270	24.0792	24.1314	24.1838	24.2361	24.2886	24.3411	24.3936	24.4462
93	24.4989	24.5516	24.6043	24.6572	24.7100	24.7630	24.8160	24.8690	24.9222	24.9753
94	25.0285	25.0818	25.1352	25.1886	25.2420	25.2955	25.3491	25.4027	25.4564	25.5101
95	25.5639	25.6177	25.6717	25.7256	25.7796	25.8337	25.8878	25.9420	25.9963	26.0506
96	26.1049	26.1593	26.2138	26.2683	26.3229	26.3776	26.4323	26.4870	26.5418	26.5966
97	26.6516	26.7066	26.7616	26.8167	26.8719	26.9271	26.9823	27.0377	27.0930	27.1485
98	27.2040	27.2595	27.3151	27.3708	27.4265	27.4823	27.5381	27.5940	27.6499	27.7059
99	27.7620	27.8181	27.8743	27.9305	27.9868	28.0431	28.0995	28.1560	28.2125	28.2690
100	28.3257	28.3823	28.4391	28.4959	28.5527	28.6096	28.6666	28.7236	28.7807	28.8378

TABLE OF THE AREAS OF CIRCLES IN IMPERIAL GALLONS.—continued.

Diame- ters in Inches.	0	1	2	3	4	5	6	7	8	9
101	28.8050	28.0522	29.0096	29.0660	29.1243	29.1818	29.2393	29.2969	29.3546	29.4123
102	29.4700	29.5278	29.5857	29.6436	29.7016	29.7596	29.8177	29.8759	29.9341	29.9924
103	30.0507	30.1091	30.1675	30.2260	30.2845	30.3432	30.4018	30.4605	30.5193	30.5781
104	30.6370	30.6960	30.7550	30.8140	30.8732	30.9323	30.9916	31.0508	31.1102	31.1696
105	31.2290	31.2886	31.3481	31.4077	31.4674	31.5272	31.5870	31.6468	31.7067	31.7667
106	31.8267	31.8868	31.9469	32.0071	32.0674	32.1277	32.1880	32.2485	32.3089	32.3695
107	32.4301	32.4907	32.5514	32.6122	32.6730	32.7338	32.7948	32.8558	32.9168	32.9779
108	33.0391	33.1003	33.1615	33.2229	33.2842	33.3457	33.4072	33.4687	33.5303	33.5920
109	33.6537	33.7155	33.7773	33.8392	33.9012	33.9632	34.0252	34.0874	34.1495	34.2118
110	34.2741	34.3364	34.3988	34.4613	34.5238	34.5863	34.6490	34.7117	34.7744	34.8372
111	34.9001	34.9630	35.0259	35.0890	35.1520	35.2152	35.2784	35.3416	35.4049	35.4683
112	35.5317	35.5952	35.6587	35.7223	35.7860	35.8497	35.9134	35.9772	36.0411	36.1051
113	36.1690	36.2331	36.2972	36.3613	36.4256	36.4898	36.5542	36.6185	36.6830	36.7475
114	36.8120	36.8766	36.9413	37.0060	37.0708	37.1357	37.20.6	37.2655	37.3305	37.3956
115	37.4607	37.5259	37.5911	37.6564	37.7217	37.7871	37.8526	37.9181	37.9837	38.0493
116	38.1150	38.1808	38.2466	38.3124	38.3783	38.4443	38.5103	38.5764	38.6426	38.7088
117	38.7750	38.8413	38.9077	38.9741	39.0406	39.1071	39.1737	39.2404	39.3071	39.3738
118	39.4407	39.5075	39.5745	39.6415	39.7085	39.7756	39.8428	39.9100	39.9773	40.0446
119	40.1120	40.1794	40.2469	40.3145	40.3821	40.4498	40.5175	40.5853	40.6531	40.7210
120	40.7890	40.8570	40.9250	40.9932	41.0613	41.1296	41.1979	41.2662	41.3346	41.4031
121	41.4716	41.5402	41.6088	41.6775	41.7463	41.8151	41.8839	41.9528	42.0218	42.0908
122	42.1599	42.2291	42.2983	42.3675	42.4368	42.5062	42.5756	42.6451	42.7147	42.7843
123	42.8539	42.9236	42.9934	43.0632	43.1331	43.2030	43.2730	43.3431	43.4132	43.4833
124	43.5536	43.6238	43.6942	43.7646	43.8350	43.9055	43.9761	44.0467	44.1173	44.1881
125	44.2589	44.3297	44.4006	44.4716	44.5426	44.6136	44.6848	44.7560	44.8272	44.8985
126	44.9698	45.0412	45.1127	45.1842	45.2558	45.3275	45.3991	45.4709	45.5427	45.6146
127	45.6865	45.7585	45.8305	45.9026	45.9747	46.0469	46.1192	46.1915	46.2639	46.3363
128	46.4088	46.4813	46.5539	46.6266	46.6993	46.7721	46.8449	46.9178	46.9907	47.0637
129	47.1368	47.2099	47.2830	47.3563	47.4295	47.5029	47.5763	47.6497	47.7232	47.7968
130	47.8704	47.9441	48.0178	48.0916	48.1654	48.2393	48.3133	48.3873	48.4614	48.5355
131	48.6097	48.6839	48.7582	48.8326	48.9070	48.9815	49.0560	49.1306	49.2052	49.2799
132	49.3547	49.4295	49.5043	49.5793	49.6542	49.7293	49.8044	49.8795	49.9547	50.0300
133	50.1053	50.1807	50.2561	50.3316	50.4071	50.4827	50.5584	50.6341	50.7099	50.7857
134	50.8616	50.9375	51.0135	51.0896	51.1657	51.2419	51.3181	51.3944	51.4707	51.5471
135	51.6235	51.7001	51.7766	51.8532	51.9299	52.0067	52.0834	52.1603	52.2372	52.3142
136	52.3912	52.4682	52.5454	52.6226	52.6998	52.7771	52.8545	52.9319	53.0094	53.0869
137	53.1645	53.2421	53.3198	53.3976	53.4754	53.5532	53.6312	53.7091	53.7872	53.8653
138	53.9434	54.0216	54.0999	54.1782	54.2566	54.3350	54.4135	54.4921	54.5707	54.6493
139	54.7280	54.8068	54.8856	54.9645	55.0435	55.1225	55.2015	55.2807	55.3598	55.4390
140	55.5183	55.5977	55.6771	55.7565	55.8360	55.9156	55.9952	56.0749	56.1546	56.2344
141	56.3143	56.3942	56.4742	56.5542	56.6343	56.7144	56.7946	56.8748	56.9551	57.0355
142	57.1159	57.1964	57.2769	57.3575	57.4381	57.5188	57.5996	57.6804	57.7613	57.8422
143	57.9232	58.0042	58.0853	58.1665	58.2477	58.3290	58.4103	58.4917	58.5731	58.6546
144	58.7361	58.8177	58.8994	58.9811	59.0629	59.1447	59.2266	59.3086	59.3906	59.4726
145	59.5547	59.6369	59.7191	59.8014	59.8838	59.9662	60.0486	60.1311	60.2137	60.2963
146	60.3790	60.4618	60.5446	60.6274	60.7103	60.7933	60.8763	60.9594	61.0425	61.1257
147	61.2090	61.2923	61.3756	61.4591	61.5425	61.6261	61.7097	61.7933	61.8770	61.9608
148	62.0446	62.1284	62.2124	62.2964	62.3804	62.4645	62.5487	62.6329	62.7171	62.8015
149	62.8858	62.9703	63.0548	63.1393	63.2239	63.3086	63.3933	63.4781	63.5629	63.6478
150	63.7328	63.8178	63.9029	63.9880	64.0731	64.1584	64.2437	64.3290	64.4144	64.4999

TABLE OF THE AREAS OF CIRCLES IN IMPERIAL GALLONS.—*continued.*

Diameters in Inches.	0	1	2	3	4	5	6	7	8	9
151	64-5854	64-6710	64-7566	64-8423	64-9280	65-0138	65-0997	65-1856	65-2716	65-3576
152	65-4437	65-5298	65-6160	65-7022	65-7886	65-8749	65-9613	66-0478	66-1344	66-2202
153	66-3076	66-3943	66-4811	66-5679	66-6548	66-7417	66-8287	66-9157	67-0028	67-0900
154	67-1772	67-2645	67-3518	67-4392	67-5266	67-6141	67-7017	67-7893	67-8770	67-9647
155	68-0525	68-1403	68-2282	68-3161	68-4041	68-4922	68-5803	68-6685	68-7567	68-8450
156	68-9334	69-0218	69-1103	69-1988	69-2873	69-3760	69-4647	69-5534	69-6422	69-7311
157	69-8200	69-9090	69-9980	70-0871	70-1763	70-2654	70-3547	70-4440	70-5333	70-6228
158	70-7122	70-8018	70-8914	70-9810	71-0707	71-1605	71-2503	71-3402	71-4301	71-5201
159	71-6102	71-7003	71-7904	71-8806	71-9709	72-0613	72-1516	72-2421	72-3326	72-4231
160	72-5138	72-6044	72-6952	72-7859	72-8768	72-9677	73-0586	73-1496	73-2407	73-3318
161	73-4230	73-5142	73-6055	73-6969	73-7883	73-8798	73-9713	74-0629	74-1545	74-2462
162	74-3379	74-4297	74-5216	74-6135	74-7055	74-7975	74-8896	74-9817	75-0739	75-1662
163	75-2585	75-3509	75-4433	75-5358	75-6283	75-7209	75-8136	75-9063	75-9991	76-0919
164	76-1848	76-2777	76-3707	76-4637	76-5569	76-6500	76-7432	76-8365	76-9298	77-0232
165	77-1167	77-2102	77-3037	77-3974	77-4910	77-5846	77-6786	77-7724	77-8663	77-9603
166	78-0543	78-1483	78-2425	78-3366	78-4309	78-5252	78-6195	78-7139	78-8084	78-9029
167	78-9975	79-0921	79-1868	79-2816	79-3764	79-4713	79-5662	79-6612	79-7562	79-8513
168	79-9464	80-0416	80-1369	80-2322	80-3276	80-4230	80-5185	80-6140	80-7096	80-8053
169	80-9010	80-9968	81-0926	81-1885	81-2844	81-3804	81-4765	81-5726	81-6687	81-7648
170	81-8612	81-9576	82-0540	82-1504	82-2469	82-3435	82-4401	82-5368	82-6335	82-7303
171	82-8271	82-9240	83-0210	83-1180	83-2151	83-3122	83-4094	83-5067	83-6039	83-7013
172	83-7987	83-8962	83-9937	84-0913	84-1889	84-2866	84-3844	84-4822	84-5801	84-6780
173	85-7589	85-8575	85-9561	86-0548	86-1536	86-2524	86-3513	86-4503	86-5493	86-6483
174	86-7474	86-8466	86-9458	87-0451	87-1444	87-2438	87-3433	87-4428	87-5424	87-6420
175	87-7417	87-8414	87-9412	88-0410	88-1409	88-2409	88-3409	88-4410	88-5411	88-6413
176	88-7416	88-8419	88-9422	89-0426	89-1431	89-2436	89-3442	89-4449	89-5455	89-6463
177	89-7471	89-8480	89-9489	90-0499	90-1509	90-2520	90-3532	90-4544	90-5556	90-6570
178	90-7583	90-8598	90-9613	91-0628	91-1644	91-2661	91-3678	91-4696	91-5714	91-6733
179	91-7752	91-8772	91-9793	92-0814	92-1836	92-2858	92-3881	92-4904	92-5928	92-6953
180	92-7978	92-9004	93-0030	93-1057	93-2084	93-3112	93-4140	93-5170	93-6199	93-7229
181	93-8260	93-9292	94-0323	94-1356	94-2389	94-3423	94-4457	94-5491	94-6527	94-7563
182	94-8599	94-9636	95-0674	95-1712	95-2750	95-3790	95-4830	95-5870	95-6911	95-7952
183	95-8995	96-0037	96-1080	96-2124	96-3169	96-4214	96-5259	96-6305	96-7352	96-8399
184	96-9447	97-0495	97-1544	97-2593	97-3644	97-4694	97-5745	97-6797	97-7849	97-8902
185	97-9950	98-1010	98-2064	98-3119	98-4175	98-5231	98-6288	98-7345	98-8403	98-9462
186	99-0521	99-1581	99-2641	99-3702	99-4763	99-5825	99-6888	99-7951	99-9014	100-007
188	100-114	100-220	100-327	100-434	100-540	100-647	100-754	100-861	100-968	101-075
189	101-182	101-289	101-396	101-503	101-610	101-718	101-825	101-933	102-040	102-148
190	102-255	102-363	102-471	102-578	102-686	102-794	102-902	103-010	103-118	103-226
191	103-335	103-443	103-551	103-659	103-768	103-876	103-985	104-093	104-202	104-311
192	104-419	104-528	104-637	104-746	104-855	104-964	105-073	105-182	105-291	105-401
193	105-510	105-619	105-729	105-838	105-948	106-057	106-167	106-277	106-386	106-496
194	106-606	106-716	106-826	106-936	107-046	107-156	107-267	107-377	107-487	107-598
195	107-708	107-818	107-929	108-040	108-150	108-261	108-372	108-483	108-594	108-705
196	108-816	108-927	109-038	109-149	109-260	109-371	109-483	109-594	109-706	109-817
197	109-929	110-040	110-152	110-264	110-376	110-487	110-599	110-711	110-823	110-935
198	111-045	111-160	111-272	111-384	111-497	111-609	111-722	111-834	111-947	112-059
199	112-172	112-285	112-398	112-511	112-624	112-737	112-850	112-963	113-076	113-188
200	113-302	113-416	113-529	113-642	113-756	113-870	113-983	114-097	114-211	114-324

TABLE OF THE AREAS OF CIRCLES IN IMPERIAL GALLONS.—continued.

Diameters in Inches.	0	1	2	3	4	5	6	7	8	9
901	114.438	114.552	114.666	114.780	114.894	115.008	115.122	115.237	115.351	115.465
902	115.580	115.694	115.809	115.923	116.038	116.153	116.267	116.382	116.497	116.619
903	116.727	116.842	116.957	117.072	117.187	117.303	117.418	117.533	117.649	117.764
904	117.880	117.995	118.111	118.227	118.342	118.458	118.574	118.690	118.806	118.922
905	119.038	119.154	119.271	119.387	119.503	119.620	119.736	119.853	119.969	120.086
906	120.202	120.319	120.436	120.553	120.670	120.787	120.904	121.021	121.138	121.255
907	121.372	121.490	121.607	121.724	121.842	121.959	122.077	122.195	122.312	122.430
908	122.548	122.666	122.784	122.902	123.020	123.138	123.256	123.374	123.492	123.611
909	123.729	123.847	123.966	124.084	124.203	124.322	124.440	124.559	124.678	124.797
910	124.916	125.035	125.154	125.273	125.392	125.511	125.631	125.750	125.869	125.989
911	126.108	126.228	126.348	126.467	126.587	126.707	126.827	126.947	127.066	127.186
912	127.307	127.427	127.547	127.667	127.787	127.907	128.028	128.149	128.269	128.390
913	128.510	128.631	128.752	128.873	128.994	129.114	129.235	129.356	129.478	129.599
914	129.720	129.841	129.962	130.084	130.205	130.327	130.448	130.570	130.692	130.813
915	130.935	131.057	131.179	131.301	131.423	131.545	131.667	131.789	131.911	132.034
916	132.156	132.278	132.401	132.523	132.646	132.768	132.891	133.014	133.137	133.260
917	133.382	133.505	133.628	133.751	133.875	133.998	134.121	134.244	134.368	134.491
918	134.615	134.738	134.862	134.985	135.109	135.233	135.357	135.480	135.604	135.728
919	135.852	135.977	136.101	136.225	136.349	136.473	136.598	136.722	136.847	136.971
920	137.096	137.221	137.345	137.470	137.595	137.720	137.845	137.970	138.095	138.220
921	138.345	138.470	138.596	138.721	138.846	138.972	139.097	139.223	139.348	139.474
922	139.600	139.726	139.852	139.977	140.103	140.229	140.356	140.482	140.608	140.734
923	140.860	140.987	141.113	141.240	141.366	141.493	141.619	141.746	141.873	142.000
924	142.127	142.253	142.380	142.508	142.635	142.762	142.889	143.016	143.144	143.271
925	143.398	143.526	143.653	143.781	143.909	144.036	144.164	144.292	144.420	144.548
926	144.676	144.804	144.932	145.060	145.188	145.317	145.445	145.573	145.702	145.830
927	145.959	146.088	146.216	146.345	146.474	146.603	146.732	146.861	146.990	147.119
928	147.248	147.377	147.506	147.636	147.765	147.894	148.024	148.153	148.283	148.413
929	148.542	148.672	148.802	148.932	149.062	149.192	149.322	149.452	149.582	149.712
930	149.842	149.973	150.103	150.234	150.364	150.495	150.625	150.756	150.887	151.017
931	151.148	151.279	151.410	151.541	151.672	151.803	151.935	152.066	152.197	152.328
932	152.460	152.591	152.723	152.854	152.986	153.118	153.249	153.381	153.513	153.645
933	153.777	153.909	154.041	154.173	154.305	154.438	154.570	154.702	154.835	154.967
934	155.100	155.232	155.365	155.498	155.630	155.763	155.896	156.029	156.162	156.295
935	156.428	156.561	156.695	156.828	156.961	157.095	157.228	157.362	157.495	157.629
936	157.762	157.896	158.030	158.164	158.298	158.432	158.566	158.700	158.834	158.968
937	159.102	159.236	159.371	159.505	159.640	159.774	159.909	160.043	160.178	160.313
938	160.448	160.582	160.717	160.852	160.987	161.122	161.258	161.393	161.528	161.663
939	161.799	161.934	162.070	162.205	162.341	162.476	162.612	162.748	162.884	163.020
940	163.156	163.292	163.428	163.564	163.700	163.836	163.972	164.109	164.245	164.382
941	164.518	164.655	164.791	164.928	165.065	165.201	165.338	165.475	165.612	165.749
942	165.886	166.023	166.160	166.298	166.435	166.572	166.710	166.847	166.985	167.122
943	167.260	167.398	167.535	167.673	167.811	167.949	168.087	168.225	168.363	168.501
944	168.639	168.778	168.916	169.054	169.193	169.331	169.470	169.608	169.747	169.886
945	170.025	170.163	170.302	170.441	170.580	170.719	170.858	170.998	171.137	171.276
946	171.415	171.555	171.694	171.834	171.973	172.113	172.253	172.392	172.532	172.673
947	172.812	172.952	173.092	173.232	173.372	173.512	173.652	173.793	173.933	174.073
948	174.214	174.354	174.495	174.636	174.776	174.917	175.058	175.199	175.340	175.481
949	175.622	175.763	175.904	176.045	176.186	176.328	176.469	176.611	176.752	176.894
950	177.035	177.177	177.319	177.460	177.602	177.744	177.886	178.028	178.170	178.312

TABLE OF THE AREAS OF CIRCLES IN IMPERIAL GALLONS.—continued.

Diameters in Inches.	0	1	2	3	4	5	6	7	8	9
251	178-454	178-596	178-739	178-881	179-024	179-166	179-308	179-451	179-594	179-736
252	179-879	180-022	180-165	180-308	180-451	180-594	180-737	180-880	181-023	181-166
253	181-310	181-453	181-596	181-740	181-883	182-027	182-170	182-314	182-458	182-602
254	182-746	182-890	183-034	183-178	183-322	183-466	183-610	183-754	183-899	184-043
255	184-187	184-332	184-476	184-621	184-766	184-910	185-055	185-200	185-345	185-490
256	185-635	185-780	185-925	186-070	186-215	186-361	186-506	186-651	186-797	186-942
257	187-088	187-234	187-379	187-525	187-671	187-817	187-963	188-108	188-255	188-401
258	188-547	188-693	188-839	188-985	189-132	189-278	189-425	189-571	189-718	189-864
259	190-011	190-158	190-305	190-452	190-599	190-746	190-893	191-040	191-187	191-334
260	191-481	191-629	191-776	191-923	192-071	192-218	192-366	192-514	192-661	192-809
261	192-957	193-105	193-253	193-401	193-549	193-697	193-845	193-993	194-142	194-290
262	194-438	194-587	194-735	194-884	195-033	195-181	195-330	195-479	195-628	195-777
263	195-926	196-075	196-224	196-373	196-522	196-671	196-821	196-970	197-119	197-269
264	197-418	197-568	197-718	197-867	198-017	198-167	198-317	198-467	198-617	198-767
265	198-917	199-067	199-217	199-367	199-518	199-668	199-819	199-969	200-120	200-270
266	200-421	200-572	200-722	200-873	201-024	201-175	201-326	201-477	201-628	201-779
267	201-931	202-082	202-233	202-385	202-536	202-688	202-839	202-991	203-143	203-294
268	203-446	203-598	203-750	203-902	204-054	204-206	204-358	204-510	204-662	204-815
269	204-967	205-120	205-272	205-425	205-577	205-730	205-883	206-035	206-188	206-341
270	206-494	206-647	206-800	206-953	207-106	207-259	207-413	207-566	207-719	207-873
271	208-026	208-180	208-333	208-487	208-641	208-795	208-948	209-102	209-256	209-410
272	209-564	209-719	209-873	210-027	210-181	210-336	210-490	210-644	210-799	210-954
273	211-108	211-263	211-418	211-572	211-727	211-882	212-037	212-192	212-347	212-502
274	212-658	212-813	212-968	213-123	213-279	213-434	213-590	213-746	213-901	214-057
275	214-213	214-368	214-524	214-680	214-836	214-992	215-148	215-305	215-461	215-617
276	215-773	215-930	216-086	216-243	216-399	216-556	216-713	216-869	217-026	217-183
277	217-340	217-497	217-654	217-811	217-968	218-125	218-282	218-440	218-597	218-754
278	218-912	219-069	219-227	219-385	219-542	219-700	219-858	220-016	220-174	220-332
279	220-490	220-648	220-806	220-964	221-122	221-281	221-439	221-597	221-756	221-914
280	222-073	222-232	222-390	222-549	222-708	222-867	223-026	223-185	223-344	223-503
281	223-662	223-821	223-981	224-140	224-299	224-459	224-618	224-778	224-937	225-097
282	225-257	225-417	225-576	225-736	225-896	226-056	226-216	226-377	226-537	226-697
283	226-857	227-018	227-178	227-338	227-498	227-658	227-820	227-981	228-142	228-302
284	228-463	228-624	228-785	228-946	229-107	229-268	229-430	229-591	229-752	229-914
285	230-075	230-237	230-398	230-560	230-721	230-883	231-045	231-207	231-369	231-530
286	231-692	231-854	232-017	232-179	232-341	232-503	232-666	232-828	232-990	233-153
287	233-316	233-478	233-641	233-804	233-966	234-129	234-292	234-455	234-618	234-781
288	234-944	235-107	235-271	235-434	235-597	235-761	235-924	236-088	236-251	236-415
289	236-579	236-742	236-906	237-070	237-234	237-398	237-562	237-726	237-890	238-054
290	238-219	238-383	238-547	238-712	238-876	239-041	239-205	239-370	239-535	239-700
291	239-864	240-029	240-194	240-359	240-524	240-689	240-855	241-020	241-185	241-350
292	241-516	241-681	241-847	242-012	242-178	242-344	242-509	242-675	242-841	243-007
293	243-173	243-339	243-505	243-671	243-837	244-003	244-170	244-336	244-503	244-669
294	244-836	245-002	245-169	245-335	245-502	245-669	245-836	246-003	246-170	246-337
295	246-504	246-671	246-838	247-006	247-173	247-340	247-508	247-675	247-843	248-010
296	248-178	248-346	248-513	248-681	248-849	249-017	249-185	249-353	249-521	249-689
297	249-858	250-026	250-194	250-363	250-531	250-700	250-868	251-037	251-206	251-374
298	251-543	251-712	251-881	252-050	252-219	252-388	252-557	252-726	252-895	253-065
299	253-234	253-404	253-573	253-743	253-912	254-082	254-251	254-421	254-591	254-761
300	254-931	255-101	255-271	255-441	255-611	255-781	255-952	256-122	256-292	256-463

TABLE OF THE AREAS OF CIRCLES IN IMPERIAL GALLONS.—continued.

Diameters in inches.	0	1	2	3	4	5	6	7	8	9
201	114-438	114-552	114-666	114-780	114-894	115-008	115-122	115-237	115-351	115-465
202	115-580	115-694	115-809	115-923	116-038	116-153	116-267	116-382	116-497	116-612
203	116-727	116-842	116-957	117-072	117-187	117-303	117-418	117-533	117-649	117-764
204	117-880	117-995	118-111	118-227	118-342	118-458	118-574	118-690	118-806	118-922
205	119-038	119-154	119-271	119-387	119-503	119-620	119-736	119-853	119-969	120-085
206	120-202	120-319	120-436	120-553	120-670	120-787	120-904	121-021	121-138	121-255
207	121-372	121-490	121-607	121-724	121-842	121-959	122-077	122-195	122-312	122-430
208	122-548	122-666	122-784	122-902	123-020	123-138	123-256	123-374	123-492	123-611
209	123-729	123-847	123-966	124-084	124-203	124-322	124-440	124-559	124-678	124-797
210	124-916	125-035	125-154	125-273	125-392	125-511	125-631	125-750	125-869	125-989
211	126-108	126-228	126-348	126-467	126-587	126-707	126-827	126-947	127-067	127-186
212	127-307	127-427	127-547	127-667	127-787	127-908	128-028	128-149	128-269	128-390
213	128-510	128-631	128-752	128-873	128-994	129-114	129-235	129-356	129-478	129-599
214	129-720	129-841	129-962	130-084	130-205	130-327	130-448	130-570	130-692	130-813
215	130-935	131-057	131-179	131-301	131-423	131-545	131-667	131-789	131-911	132-034
216	132-156	132-278	132-401	132-523	132-646	132-768	132-891	133-014	133-137	133-260
217	133-382	133-505	133-628	133-751	133-875	133-998	134-121	134-244	134-367	134-491
218	134-615	134-738	134-862	134-985	135-109	135-233	135-357	135-480	135-604	135-728
219	135-852	135-977	136-101	136-225	136-349	136-473	136-598	136-722	136-847	136-971
220	137-096	137-221	137-345	137-470	137-595	137-720	137-845	137-970	138-095	138-220
221	138-345	138-470	138-596	138-721	138-846	138-972	139-097	139-223	139-348	139-474
222	139-600	139-726	139-852	139-977	140-103	140-229	140-356	140-482	140-608	140-734
223	140-860	140-987	141-113	141-240	141-366	141-493	141-619	141-746	141-873	142-000
224	142-127	142-253	142-380	142-508	142-635	142-762	142-889	143-016	143-144	143-271
225	143-398	143-526	143-653	143-781	143-909	144-036	144-164	144-292	144-420	144-548
226	144-676	144-804	144-932	145-060	145-188	145-317	145-445	145-573	145-702	145-830
227	145-959	146-088	146-216	146-345	146-474	146-603	146-732	146-861	146-990	147-119
228	147-248	147-377	147-506	147-636	147-765	147-894	148-024	148-153	148-283	148-413
229	148-542	148-672	148-802	148-932	149-062	149-192	149-322	149-452	149-582	149-712
230	149-842	149-973	150-103	150-234	150-364	150-495	150-625	150-756	150-887	151-017
231	151-148	151-279	151-410	151-541	151-672	151-803	151-935	152-066	152-197	152-328
232	152-460	152-591	152-723	152-854	152-986	153-118	153-249	153-381	153-513	153-645
233	153-777	153-909	154-041	154-173	154-305	154-438	154-570	154-702	154-835	154-967
234	155-100	155-232	155-365	155-498	155-630	155-763	155-896	156-029	156-162	156-295
235	156-428	156-561	156-695	156-828	156-961	157-095	157-228	157-362	157-495	157-629
236	157-762	157-896	158-030	158-164	158-298	158-432	158-566	158-700	158-834	158-968
237	159-102	159-236	159-371	159-505	159-640	159-774	159-909	160-043	160-178	160-313
238	160-448	160-582	160-717	160-852	160-987	161-122	161-258	161-393	161-528	161-663
239	161-799	161-934	162-070	162-205	162-341	162-476	162-612	162-747	162-884	163-020
240	163-156	163-292	163-428	163-564	163-700	163-836	163-972	164-109	164-245	164-382
241	164-518	164-655	164-791	164-928	165-065	165-201	165-338	165-475	165-612	165-749
242	165-886	166-023	166-160	166-298	166-435	166-572	166-710	166-847	166-985	167-122
243	167-260	167-398	167-535	167-673	167-811	167-949	168-087	168-225	168-363	168-501
244	168-639	168-778	168-916	169-054	169-193	169-331	169-470	169-608	169-747	169-886
245	170-025	170-163	170-302	170-441	170-580	170-719	170-858	170-998	171-137	171-276
246	171-415	171-555	171-694	171-834	171-973	172-113	172-253	172-392	172-532	172-672
247	172-812	172-952	173-092	173-232	173-372	173-512	173-652	173-793	173-933	174-073
248	174-214	174-354	174-495	174-636	174-776	174-917	175-058	175-199	175-340	175-481
249	175-622	175-763	175-904	176-045	176-186	176-328	176-469	176-611	176-752	176-894
250	177-035	177-177	177-319	177-460	177-602	177-744	177-886	178-028	178-170	178-313

TABLE OF THE AREAS OF CIRCLES IN IMPERIAL GALLONS.—continued.

Diameters in Inches.	0	1	2	3	4	5	6	7	8	9
251	178-454	178-596	178-739	178-881	179-024	179-166	179-308	179-451	179-594	179-736
252	179-879	180-022	180-165	180-308	180-451	180-594	180-737	180-880	181-023	181-166
253	181-310	181-453	181-596	181-740	181-883	182-027	182-170	182-314	182-458	182-602
254	182-746	182-890	183-034	183-178	183-322	183-466	183-610	183-754	183-899	184-043
255	184-187	184-332	184-476	184-621	184-766	184-910	185-055	185-200	185-345	185-490
256	185-635	185-780	185-925	186-070	186-215	186-361	186-506	186-651	186-797	186-942
257	187-088	187-234	187-379	187-525	187-671	187-817	187-963	188-108	188-255	188-401
258	188-547	188-693	188-839	188-985	189-132	189-278	189-425	189-571	189-718	189-864
259	190-011	190-158	190-305	190-452	190-599	190-746	190-893	191-040	191-187	191-334
260	191-481	191-629	191-776	191-923	192-071	192-218	192-366	192-514	192-661	192-809
261	192-957	193-105	193-253	193-401	193-549	193-697	193-845	193-993	194-142	194-290
262	194-438	194-587	194-735	194-884	195-033	195-181	195-330	195-479	195-628	195-777
263	195-926	196-075	196-224	196-373	196-522	196-671	196-821	196-970	197-119	197-269
264	197-418	197-568	197-718	197-867	198-017	198-167	198-317	198-467	198-617	198-767
265	198-917	199-067	199-217	199-367	199-518	199-668	199-819	199-969	200-120	200-270
266	200-420	200-572	200-729	200-873	201-024	201-175	201-326	201-477	201-628	201-779
267	201-931	202-082	202-233	202-385	202-536	202-688	202-839	202-991	203-143	203-294
268	203-446	203-598	203-750	203-902	204-054	204-206	204-358	204-510	204-662	204-815
269	204-967	205-120	205-272	205-425	205-577	205-730	205-883	206-035	206-188	206-341
270	206-494	206-647	206-800	206-953	207-106	207-259	207-413	207-566	207-719	207-873
271	208-026	208-180	208-333	208-487	208-641	208-795	208-948	209-102	209-256	209-410
272	209-564	209-719	209-873	210-027	210-181	210-336	210-490	210-644	210-799	210-954
273	211-108	211-263	211-418	211-572	211-727	211-882	212-037	212-192	212-347	212-502
274	212-658	212-813	212-968	213-123	213-279	213-434	213-590	213-746	213-901	214-057
275	214-213	214-368	214-524	214-680	214-836	214-992	215-148	215-305	215-461	215-617
276	215-773	215-930	216-086	216-243	216-399	216-556	216-713	216-869	217-026	217-183
277	217-340	217-497	217-654	217-811	217-968	218-125	218-282	218-440	218-597	218-754
278	218-912	219-069	219-227	219-385	219-542	219-700	219-858	220-016	220-174	220-332
279	220-490	220-648	220-806	220-964	221-122	221-281	221-439	221-597	221-756	221-914
280	222-073	222-232	222-390	222-549	222-708	222-867	223-026	223-185	223-344	223-503
281	223-662	223-821	223-981	224-140	224-299	224-459	224-618	224-778	224-937	225-097
282	225-257	225-417	225-576	225-736	225-896	226-056	226-216	226-377	226-537	226-697
283	226-857	227-018	227-178	227-338	227-499	227-660	227-820	227-981	228-142	228-302
284	228-463	228-624	228-785	228-946	229-107	229-268	229-430	229-591	229-752	229-914
285	230-075	230-237	230-398	230-560	230-721	230-883	231-045	231-207	231-369	231-530
286	231-692	231-854	232-017	232-179	232-341	232-503	232-666	232-828	232-990	233-153
287	233-316	233-478	233-641	233-804	233-966	234-129	234-292	234-455	234-618	234-781
288	234-944	235-107	235-271	235-434	235-597	235-761	235-924	236-088	236-251	236-415
289	236-579	236-742	236-906	237-070	237-234	237-398	237-562	237-726	237-890	238-054
290	238-219	238-383	238-547	238-712	238-876	239-041	239-205	239-370	239-535	239-700
291	239-864	240-029	240-194	240-359	240-524	240-689	240-855	241-020	241-185	241-350
292	241-516	241-681	241-847	242-012	242-178	242-344	242-509	242-675	242-841	243-007
293	243-173	243-339	243-505	243-671	243-837	244-003	244-170	244-336	244-503	244-669
294	244-836	245-002	245-169	245-335	245-502	245-669	245-836	246-003	246-170	246-337
295	246-504	246-671	246-838	247-006	247-173	247-340	247-508	247-675	247-843	248-010
296	248-178	248-346	248-513	248-681	248-849	249-017	249-185	249-353	249-521	249-689
297	249-858	250-026	250-194	250-363	250-531	250-700	250-868	251-037	251-206	251-374
298	251-543	251-712	251-881	252-050	252-219	252-388	252-557	252-726	252-895	253-065
299	253-234	253-404	253-573	253-743	253-912	254-082	254-251	254-421	254-591	254-761
300	254-931	255-101	255-271	255-441	255-611	255-781	255-952	256-122	256-292	256-463

No. 41.

TABLE OF THE AREAS OF CIRCLES IN GALLONS, CALCULATED FROM THEIR CIRCUMFERENCES.

Circum- ference.	Area in Galls.	Circum- ference.	Area in Galls.	Circum- ference.	Area in Galls.	Circum- ference.	Area in Galls.	Circum- ference.	Area in Galls.	Circum- ference.	Area in Galls.
1	0003	51	7465	101	29277	151	65439	201	115961	251	180613
2	0012	52	7760	102	29869	152	66306	202	117107	252	182256
3	0026	53	8062	103	30448	153	67184	203	118270	253	183706
4	0046	54	8369	104	31042	154	68065	204	119438	254	185161
5	0072	55	8682	105	31642	155	68952	205	120612	255	186622
6	0103	56	9000	106	32247	156	69844	206	121791	256	188088
7	0141	57	9324	107	32858	157	70743	207	122977	257	189561
8	0184	58	9654	108	33476	158	71647	208	124168	258	191039
9	0232	59	9990	109	34098	159	72556	209	125364	259	192522
10	0287	60	10332	110	34727	160	73472	210	126567	260	194012
11	0347	61	10679	111	35361	161	74393	211	127775	261	195507
12	0413	62	11032	112	36001	162	75320	212	128989	262	197008
13	0485	63	11391	113	36647	163	76253	213	130209	263	198515
14	0562	64	11755	114	37299	164	77192	214	131434	264	200027
15	0645	65	12126	115	37956	165	78136	215	132666	265	201546
16	0734	66	12502	116	38619	166	79086	216	133903	266	203070
17	0829	67	12883	117	39287	167	80041	217	135145	267	204599
18	0930	68	13271	118	39962	168	81003	218	136394	268	206135
19	1036	69	13664	119	40642	169	81970	219	137648	269	207676
20	1148	70	14063	120	41328	170	82943	220	138908	270	209223
21	1265	71	14468	121	42020	171	83922	221	140174	271	210776
22	1389	72	14878	122	42717	172	84906	222	141445	272	212334
23	1518	73	15294	123	43420	173	85896	223	142722	273	213898
24	1653	74	15716	124	44129	174	86892	224	144005	274	215468
25	1794	75	16144	125	44844	175	87894	225	145294	275	217044
26	1940	76	16577	126	45564	176	88901	226	146588	276	218625
27	2092	77	17016	127	46290	177	89914	227	147888	277	220212
28	2250	78	17461	128	47022	178	90933	228	149194	278	221806
29	2414	79	17912	129	47760	179	91957	229	150506	279	223404
30	2583	80	18368	130	48503	180	92988	230	151823	280	225006
31	2758	81	18830	131	49252	181	94024	231	153146	281	226618
32	2939	82	19298	132	50007	182	95066	232	154474	282	228234
33	3125	83	19771	133	50767	183	96114	233	155800	283	229855
34	3318	84	20251	134	51534	184	97167	234	157150	284	231483
35	3516	85	20736	135	52306	185	98226	235	158496	285	233118
36	3719	86	21226	136	53084	186	99290	236	159847	286	234754
37	3929	87	21723	137	53867	187	100361	237	161205	287	236399
38	4144	88	22225	138	54656	188	101437	238	162568	288	238049
39	4365	89	22733	139	55451	189	102519	239	163937	289	239705
40	4592	90	23247	140	56252	190	103607	240	165312	290	241367
41	4824	91	23765	141	57058	191	104700	241	166692	291	243034
42	5063	92	24282	142	57871	192	105800	242	168079	292	244708
43	5307	93	24823	143	58689	193	106906	243	169471	293	246387
44	5556	94	25369	144	59512	194	108015	244	170868	294	248071
45	5812	95	25901	145	60342	195	109132	245	172272	295	249762
46	6073	96	26450	146	61177	196	110254	246	173681	296	251458
47	6340	97	27004	147	62018	197	111382	247	175096	297	253160
48	6612	98	27563	148	62864	198	112515	248	176516	298	254867
49	6891	99	28129	149	63717	199	113655	249	177943	299	256581
50	7175	100	28700	150	64575	200	114800	250	179375	300	258300

No. 42.—TABLE SHOWING THE QUANTITY OF WATER NECESSARY TO REDUCE PROOF SPIRITS TO THE FOLLOWING STRENGTHS.

Quarts.	Pts.	Strength u. p.	Quarts.	Pts.	Strength u. p.	Quarts.	Pts.	Strength u. p.	Quarts.	Pts.	Strength u. p.
		16		1	12.5		1	23.4		1	32.8
		3.1		1	14.1		1	25.0		1	34.4
		4.7		1	15.6		1	26.6		1	35.9
		6.2		1	17.2		1	28.1		1	37.5
		7.8		1	18.8		1	29.7		1	39.1
		9.4		1	20.3		1	31.2		1	40.6
		11.0		1	21.9		1			2	
										1 1/2	42.2
										1 3/4	43.8
										1 1/2	45.3
										1 1/2	46.4
										1 1/2	48.4
										2	50.0

Example.—If $1\frac{1}{2}$ pint of water be put into a gallon measure, and the measure filled up with proof spirit: the spirit will be reduced to 14.1 per cent. u. p.—*Nisbett's Gauging.*

No. 43.—TABLE SHOWING THE QUANTITY OF WATER NECESSARY TO REDUCE SPIRITS OF 22 PER CENT. U. P. TO THE FOLLOWING STRENGTHS.

Quarts.	Pts.	Strength u. p.	Quarts.	Pts.	Strength u. p.	Quarts.	Pts.	Strength u. p.	Quarts.	Pts.	Strength u. p.
		23.2		1	31.8		1 1/2	40.3		1	47.6
		24.4		1	33.0		1	41.5		1	48.8
		25.7		1	34.2		1	42.7		1	50.0
		26.9		1	35.4		1	43.9		1	51.2
		28.1		1	36.6		1	45.2		1	52.5
		29.3		1	37.8		1	46.4		1	53.7
		30.5		1	39.1		1			2	
										1 1/2	54.9
										1 1/2	56.1
										1 1/2	57.3
										1 1/2	58.6
										1 1/2	59.8
										2	61.0

Example.—If $1\frac{1}{2}$ pint of water be put into a gallon measure, and the measure be filled up with spirits of 22 per cent. u. p., the spirit will be reduced to 34.2 per cent. u. p.

No. 44.—TABLE SHOWING THE QUANTITY OF SPIRITS OF 22 U. P. TO BE ADDED TO SPIRITS OF 61 U. P. TO RAISE THE STRENGTH AS FOLLOWS.

Quarts.	Pts.	Strength u. p.	Quarts.	Pts.	Strength u. p.	Quarts.	Pts.	Strength u. p.	Quarts.	Pts.	Strength u. p.
		60.4		1 1/2	52.5		1	44.5		2	36.6
		59.8		1 1/2	51.9		1	43.9		2	35.0
		59.2		1	51.3		1	43.3		2	35.4
		58.6		1	50.6		1	42.7		2	34.8
		58.0		1	50.0		1	42.1		2	34.2
		57.3		1	49.4		2	41.5		2	33.6
		56.7		1	48.8		2	40.9		2	33.0
		56.1		1	48.2		2	40.3		2	32.4
		55.5		1	47.6		2	39.7		3	31.8
		54.9		1	47.0		2	39.0		3	31.1
		54.3		1	46.4		2	38.4		3	30.5
		53.7		1	45.8		2	37.8		3	29.9
		53.1		1	45.2		2	37.2		4	29.3
										1 1/2	28.7
										1 1/2	28.1
										1 1/2	27.7
										1 1/2	26.4
										1 1/2	26.0
										1 1/2	25.7
										1 1/2	25.4
										1 1/2	24.1
										1 1/2	23.8
										1 1/2	23.5
										1 1/2	22.2
										1 1/2	22.0

Example.—If 1 quart and $\frac{1}{2}$ of a pint of spirits at 22 per cent. u. p. be put into a gallon measure, and such measure filled up with spirits at 61 per cent. u. p., the strength of the spirit will be raised to 50.6 per cent. u. p.

No. 41.

TABLE OF THE AREAS OF CIRCLES IN GALLONS, CALCULATED FROM THEIR CIRCUMFERENCES.

Circumference.	Area in Gallons.	Circumference.	Area in Gallons.	Circumference.	Area in Gallons.	Circumference.	Area in Gallons.	Circumference.	Area in Gallons.	Circumference.	Area in Gallons.
1	0008	51	7466	101	29277	151	65439	201	115951	251	180813
2	0012	52	7760	102	29869	152	66308	202	117107	252	182256
3	0026	53	8062	103	30448	153	67184	203	118270	253	183706
4	0046	54	8369	104	31042	154	68065	204	119438	254	185161
5	0072	55	8682	105	31642	155	68952	205	120612	255	186622
6	0103	56	9000	106	32247	156	69844	206	121791	256	188088
7	0141	57	9324	107	32858	157	70743	207	122977	257	189561
8	0184	58	9654	108	33476	158	71647	208	124168	258	191039
9	0232	59	9990	109	34098	159	72556	209	125364	259	192522
10	0287	60	10332	110	34727	160	73472	210	126567	260	194012
11	0347	61	10679	111	35361	161	74393	211	127775	261	195507
12	0413	62	11032	112	36001	162	75320	212	128989	262	197006
13	0485	63	11391	113	36647	163	76253	213	130209	263	198515
14	0562	64	11755	114	37299	164	77192	214	131434	264	200027
15	0645	65	12126	115	37956	165	78136	215	132666	265	201546
16	0734	66	12502	116	38619	166	79086	216	133903	266	203070
17	0829	67	12883	117	39287	167	80041	217	135145	267	204599
18	0930	68	13271	118	39962	168	81003	218	136394	268	206135
19	1036	69	13664	119	40642	169	81970	219	137648	269	207676
20	1148	70	14063	120	41328	170	82943	220	138908	270	209223
21	1265	71	14468	121	42020	171	83922	221	140174	271	210776
22	1389	72	14878	122	42717	172	84906	222	141445	272	212334
23	1518	73	15294	123	43420	173	85896	223	142722	273	213898
24	1653	74	15716	124	44129	174	86892	224	144005	274	215468
25	1794	75	16144	125	44844	175	87894	225	145294	275	217044
26	1940	76	16577	126	45564	176	88901	226	146588	276	218625
27	2092	77	17016	127	46290	177	89914	227	147888	277	220212
28	2250	78	17461	128	47022	178	90933	228	149194	278	221805
29	2414	79	17912	129	47760	179	91957	229	150506	279	223404
30	2583	80	18368	130	48503	180	92986	230	151823	280	225008
31	2758	81	18830	131	49252	181	94024	231	153146	281	226618
32	2939	82	19298	132	50007	182	95066	232	154474	282	228234
33	3125	83	19771	133	50767	183	96114	233	155809	283	229855
34	3318	84	20251	134	51534	184	97167	234	157150	284	231483
35	3516	85	20736	135	52306	185	98226	235	158496	285	233116
36	3719	86	21226	136	53084	186	99290	236	159847	286	234754
37	3929	87	21723	137	53867	187	100361	237	161205	287	236399
38	4144	88	22225	138	54656	188	101437	238	162568	288	238049
39	4365	89	22733	139	55451	189	102519	239	163937	289	239705
40	4592	90	23247	140	56252	190	103607	240	165312	290	241367
41	4824	91	23766	141	57058	191	104700	241	166692	291	243034
42	5063	92	24292	142	57871	192	105800	242	168079	292	244706
43	5307	93	24823	143	58689	193	106905	243	169471	293	246387
44	5556	94	25359	144	59512	194	108015	244	170868	294	248071
45	5812	95	25901	145	60342	195	109132	245	172272	295	249762
46	6073	96	26450	146	61177	196	110254	246	173681	296	251468
47	6340	97	27004	147	62018	197	111382	247	175096	297	253180
48	6612	98	27563	148	62864	198	112515	248	176516	298	254897
49	6891	99	28129	149	63717	199	113655	249	177943	299	256621
50	7175	100	28700	150	64575	200	114800	250	179375	300	258350

No. 42.—TABLE SHOWING THE QUANTITY OF WATER NECESSARY TO REDUCE PROOF SPIRITS TO THE FOLLOWING STRENGTHS.

Quarts.	Pts.	Strength u. p.	Quarts.	Pts.	Strength u. p.	Quarts.	Pts.	Strength u. p.	Quarts.	Pts.	Strength u. p.
		1-6		1	12-5		1	23-4		1	32-8
		3-1		1	14-1		1	25-0		1	34-4
		4-7		1	15-6		1	26-6		1	35-9
		6-2		1	17-2		1	28-1		1	37-5
		7-8		1	18-8		1	29-7		1	39-1
		9-4		1	20-3		1	31-2		1	40-6
		11-0		1	21-9		1			2	

Example.—If $1\frac{1}{4}$ pint of water be put into a gallon measure, and the measure filled up with proof spirit: the spirit will be reduced to 14-1 per cent. u. p.—*Nisbett's Gauging.*

No. 43.—TABLE SHOWING THE QUANTITY OF WATER NECESSARY TO REDUCE SPIRITS OF 22 PER CENT. U. P. TO THE FOLLOWING STRENGTHS.

Quarts.	Pts.	Strength u. p.	Quarts.	Pts.	Strength u. p.	Quarts.	Pts.	Strength u. p.	Quarts.	Pts.	Strength u. p.
		23-2		1	31-8		1	40-3		1	47-6
		24-4		1	33-0		1	41-5		1	48-8
		25-7		1	34-2		1	42-7		1	50-0
		26-9		1	35-4		1	43-9		1	51-2
		28-1		1	36-6		1	45-2		1	52-5
		29-3		1	37-8		1	46-4		1	53-7
		30-5		1	39-1		1			2	

Example.—If $1\frac{1}{4}$ pint of water be put into a gallon measure, and the measure be filled up with spirits of 22 per cent. u. p., the spirit will be reduced to 34-2 per cent. u. p.

No. 44.—TABLE SHOWING THE QUANTITY OF SPIRITS OF 22 U. P. TO BE ADDED TO SPIRITS OF 61 U. P. TO RAISE THE STRENGTH AS FOLLOWS.

Quarts.	Pts.	Strength u. p.	Quarts.	Pts.	Strength u. p.	Quarts.	Pts.	Strength u. p.	Quarts.	Pts.	Strength u. p.
		60-4		1	52-5		1	44-5		1	36-6
		59-8		1	51-9		1	43-9		1	36-0
		59-2		1	51-3		1	43-3		1	35-4
		58-6		1	50-6		1	42-7		1	34-8
		58-0		1	50-0		1	42-1		1	34-2
		57-3		1	49-4		2	41-5		1	33-6
		56-7		1	48-8		2	40-9		1	33-0
		56-1		1	48-2		2	40-3		1	32-4
		55-5		1	47-6		2	39-7		1	31-8
		54-9		1	47-0		2	39-0		1	31-1
		54-3		1	46-4		2	38-4		1	30-5
		53-7		1	45-8		2	37-8		1	29-9
		53-1		1	45-2		2	37-2		1	29-3

Example.—If 1 quart and $\frac{1}{4}$ of a pint of spirits at 22 per cent. u. p. be put into a gallon measure, and such measure filled up with spirits at 61 per cent. u. p., the strength of the spirit will be raised to 50-6 per cent. u. p.

No. 45.

AREAS OF THE HEAD DIAMETERS OF CASKS.

Inch.	0	1	2	3	4	5	6	7	8	9
10	·0944	·0963	·0982	·1001	·1021	·1041	·1061	·1081	·1101	·1122
11	·1142	·1163	·1184	·1205	·1227	·1248	·1271	·1293	·1315	·1337
12	·1360	·1382	·1405	·1428	·1452	·1475	·1499	·1523	·1547	·1571
13	·1596	·1620	·1645	·1670	·1695	·1721	·1746	·1772	·1798	·1824
14	·1851	·1877	·1904	·1931	·1958	·1985	·2013	·2040	·2068	·2096
15	·2124	·2153	·2181	·2210	·2239	·2268	·2298	·2327	·2357	·2387
16	·2417	·2447	·2478	·2509	·2539	·2571	·2602	·2633	·2665	·2697
17	·2729	·2761	·2793	·2826	·2859	·2892	·2925	·2958	·2992	·3025
18	·3059	·3093	·3128	·3164	·3197	·3231	·3267	·3302	·3337	·3373
19	·3409	·3445	·3481	·3517	·3554	·3590	·3627	·3664	·3702	·3739
20	·3777	·3815	·3853	·3891	·3929	·3968	·4007	·4046	·4085	·4124
21	·4164	·4204	·4244	·4284	·4324	·4365	·4405	·4446	·4487	·4528
22	·4570	·4612	·4653	·4695	·4738	·4780	·4823	·4865	·4908	·4951
23	·4995	·5038	·5082	·5126	·5170	·5214	·5260	·5303	·5348	·5393
24	·5439	·5484	·5530	·5575	·5621	·5668	·5714	·5760	·5807	·5854
25	·5901	·5948	·5996	·6044	·6092	·6140	·6188	·6236	·6285	·6334
26	·6383	·6432	·6481	·6531	·6581	·6631	·6681	·6731	·6782	·6832
27	·6883	·6934	·6986	·7037	·7089	·7140	·7192	·7245	·7297	·7350
28	·7402	·7455	·7509	·7562	·7615	·7669	·7723	·7777	·7831	·7886
29	·7941	·7996	·8051	·8106	·8161	·8217	·8273	·8329	·8385	·8441
30	·8498	·8554	·8611	·8669	·8726	·8783	·8841	·8899	·8957	·9015
31	·9074	·9132	·9191	·9250	·9309	·9368	·9428	·9488	·9548	·9608
32	·9669	·9729	·9790	·9851	·9912	·9973	1·0034	1·0096	1·0158	1·0220
33	1·0282	1·0345	1·0407	1·0470	1·0533	1·0596	1·0660	1·0723	1·0787	1·0851
34	1·0915	1·0979	1·1044	1·1108	1·1173	1·1238	1·1303	1·1369	1·1435	1·1500
35	1·1566	1·1633	1·1699	1·1765	1·1832	1·1899	1·1966	1·2034	1·2101	1·2169
36	1·2237	1·2305	1·2373	1·2442	1·2510	1·2579	1·2648	1·2717	1·2787	1·2856
37	1·2926	1·2996	1·3066	1·3136	1·3207	1·3278	1·3349	1·3420	1·3491	1·3562
38	1·3634	1·3706	1·3778	1·3850	1·3923	1·3995	1·4068	1·4141	1·4214	1·4288
39	1·4361	1·4435	1·4509	1·4583	1·4657	1·4732	1·4806	1·4881	1·4956	1·5032
40	1·5107	1·5183	1·5258	1·5335	1·5411	1·5487	1·5564	1·5640	1·5717	1·5795
41	1·5872	1·5949	1·6027	1·6105	1·6183	1·6261	1·6340	1·6418	1·6497	1·6576
42	1·6656	1·6735	1·6815	1·6894	1·6974	1·7054	1·7135	1·7215	1·7296	1·7377
43	1·7458	1·7539	1·7621	1·7703	1·7784	1·7866	1·7949	1·8031	1·8114	1·8197
44	1·8280	1·8363	1·8446	1·8530	1·8613	1·8697	1·8781	1·8866	1·8950	1·9035
45	1·9120	1·9205	1·9290	1·9376	1·9461	1·9547	1·9633	1·9719	1·9806	1·9892
46	1·9979	2·0066	2·0153	2·0241	2·0328	2·0416	2·0504	2·0592	2·0680	2·0769
47	2·0857	2·0946	2·1035	2·1124	2·1214	2·1303	2·1393	2·1483	2·1573	2·1664
48	2·1754	2·1845	2·1936	2·2027	2·2118	2·2210	2·2301	2·2393	2·2485	2·2578

No. 47.

TABLE OF DIFFERENCES BETWEEN

Inch.	0	1	2	3	4	5	6	7	8	9
1	·00037	·00045	·00054	·00063	·00074	·00084	·00096	·00109	·00122	·00136
2	·01151	·00166	·00183	·00199	·00217	·00236	·00255	·00275	·00296	·00317
3	·00339	·00362	·00386	·00411	·00436	·00462	·00489	·00517	·00545	·00574
4	·00604	·00634	·00666	·00698	·00731	·00764	·00799	·00834	·00870	·00906
5	·00944	·00982	·01021	·01060	·01101	·01142	·01184	·01227	·01270	·01314
6	·01359	·01405	·01451	·01499	·01547	·01595	·01645	·01695	·01746	·01798
7	·01850	·01903	·01957	·02012	·02068	·02124	·02181	·02239	·02297	·02357
8	·02417	·02478	·02539	·02601	·02665	·02728	·02793	·02858	·02923	·02991

No. 46.

AREAS OF THE BUNG DIAMETERS OF CASKS.

Inch.	0	1	2	3	4	5	6	7	8	9
12	2719	2765	2811	2857	2904	2951	2998	3046	3094	3142
13	3191	3241	3290	3340	3391	3442	3493	3544	3596	3649
14	3701	3754	3808	3862	3916	3970	4025	4081	4136	4192
15	4249	4306	4363	4421	4478	4537	4596	4655	4714	4774
16	4834	4896	4956	5017	5079	5141	5204	5267	5330	5393
17	5457	5522	5587	5652	5717	5783	5849	5916	5983	6051
18	6118	6187	6255	6324	6393	6463	6533	6603	6674	6745
19	6817	6889	6961	7034	7107	7181	7254	7329	7403	7478
20	7554	7629	7705	7782	7859	7936	8014	8092	8170	8249
21	8328	8407	8487	8567	8648	8729	8810	8892	8974	9057
22	9140	9223	9307	9391	9475	9560	9645	9731	9817	9903
23	9990	10077	10164	10252	10340	10429	10518	10607	10697	10787
24	10877	10968	11059	11151	11243	11336	11428	11521	11614	11708
25	11802	11897	11992	12087	12183	12279	12376	12473	12570	12667
26	12765	12864	12963	13062	13161	13261	13361	13462	13563	13665
27	13766	13868	13971	14074	14177	14281	14385	14489	14594	14699
28	14806	14911	15017	15124	15231	15338	15446	15554	15663	15772
29	15881	15991	16101	16212	16322	16434	16545	16657	16770	16882
30	16995	17109	17223	17337	17452	17567	17682	17798	17914	18030
31	18147	18265	18382	18500	18619	18737	18857	18976	19096	19216
32	19337	19458	19579	19701	19823	19946	20069	20192	20316	20440
33	20664	20789	20914	21040	21166	21292	21419	21546	21674	21801
34	21930	22058	22187	22316	22446	22576	22707	22838	22969	23101
35	23133	23265	23398	23531	23664	23798	23933	24067	24202	24338
36	24473	24610	24746	24883	25020	25158	25296	25434	25573	25712
37	25852	25992	26132	26273	26414	26556	26697	26839	26982	27125
38	27268	27412	27556	27700	27845	27991	28136	28282	28428	28575
39	28722	28870	29018	29166	29314	29463	29613	29763	29913	30063
40	30214	30365	30517	30669	30821	30974	31127	31281	31435	31589
41	31744	31899	32054	32210	32366	32523	32680	32837	32995	33153
42	33311	33470	33629	33789	33949	34109	34270	34431	34592	34754
43	34916	35079	35242	35405	35569	35733	35897	36062	36227	36393
44	36559	36725	36892	37059	37227	37395	37563	37732	37901	38070
45	38240	38410	38580	38751	38923	39094	39266	39439	39611	39785
46	39958	40132	40306	40481	40656	40832	41007	41183	41360	41537
47	41714	41892	42070	42249	42427	42607	42786	42966	43146	43327
48	43508	43690	43872	44054	44236	44419	44603	44787	44971	45155
49	45340	45525	45711	45897	46083	46270	46457	46645	46833	47021
50	47210	47399	47588	47778	47968	48158	48349	48541	48732	48924

No. 47.—continued.

THE HEAD AND BUNG DIAMETERS.

Inch.	0	1	2	3	4	5	6	7	8	9
9	09059	09127	09196	09266	09337	09408	09480	09553	09627	09701
10	09777	09852	09929	04007	04085	04164	04243	04324	04405	04487
11	04570	04653	04737	04822	04908	05004	05082	05170	05259	05348
12	05438	05529	05621	05714	05807	05901	05996	06091	06188	06285
13	06383	06481	06581	06681	06781	06883	06985	07089	07192	07297
14	07393	07509	07615	07723	07831	07941	08051	08161	08273	08386
15	08498	08611	08726	08841	08957	09074	09191	09309	09428	09548

No. 48.

TABLE OF A DIAGONAL LINE FOR CASK GAUGING.

Diagonal Line in inches and decimal parts of an Inch.	Gallons.	Diagonal Line in inches and decimal parts of an Inch.	Gallons.	Diagonal Line in inches and decimal parts of an Inch.	Gallons.	Diagonal Line in inches and decimal parts of an Inch.	Gallons.
6-04	1	28-21	51	35-42	101	40-5	151
7-61	1	28-39	52	35-54	102	40-59	152
9-58	2	28-57	53	35-65	103	40-68	153
10-97	3	28-75	54	35-77	104	40-77	154
12-07	4	28-92	55	35-88	105	40-86	155
13-01	5	29-1	56	36	106	40-94	156
13-82	6	29-27	57	36-11	107	41-03	157
14-55	7	29-44	58	36-22	108	41-12	158
15-21	8	29-61	59	36-33	109	41-2	159
15-82	9	29-78	60	36-44	110	41-29	160
16-39	10	29-94	61	36-55	111	41-38	161
16-92	11	30-1	62	36-66	112	41-46	162
17-41	12	30-26	63	36-77	113	41-55	163
17-88	13	30-42	64	36-88	114	41-63	164
18-33	14	30-58	65	36-99	115	41-72	165
18-76	15	30-74	66	37-09	116	41-8	166
19-17	16	30-89	67	37-2	117	41-88	167
19-56	17	31-04	68	37-3	118	41-97	168
19-93	18	31-2	69	37-41	119	42-06	169
20-3	19	31-35	70	37-52	120	42-14	170
20-65	20	31-49	71	37-62	121	42-21	171
20-98	21	31-64	72	37-72	122	42-3	172
21-31	22	31-79	73	37-82	123	42-38	173
21-63	23	31-93	74	37-93	124	42-46	174
21-95	24	32-08	75	38-03	125	42-54	175
22-24	25	32-22	76	38-13	126	42-62	176
22-53	26	32-36	77	38-23	127	42-7	177
22-82	27	32-5	78	38-33	128	42-78	178
23-1	28	32-64	79	38-43	129	42-87	179
23-37	29	32-77	80	38-53	130	42-95	180
23-63	30	32-91	81	38-63	131	43-02	181
23-89	31	33-04	82	38-73	132	43-1	182
24-15	32	33-18	83	38-83	133	43-18	183
24-4	33	33-31	84	38-92	134	43-26	184
24-64	34	33-44	85	39-02	135	43-34	185
24-88	35	33-57	86	39-11	136	43-42	186
25-11	36	33-7	87	39-21	137	43-49	187
25-34	37	33-83	88	39-3	138	43-57	188
25-57	38	33-96	89	39-4	139	43-65	189
25-79	39	34-08	90	39-49	140	43-73	190
26-01	40	34-21	91	39-59	141	43-8	191
26-23	41	34-34	92	39-68	142	43-88	192
26-44	42	34-46	93	39-77	143	43-95	193
26-65	43	34-58	94	39-87	144	44-03	194
26-85	44	34-7	95	39-96	145	44-1	195
27-05	45	34-83	96	40-05	146	44-18	196
27-25	46	34-95	97	40-14	147	44-26	197
27-45	47	35-06	98	40-23	148	44-33	198
27-64	48	35-19	99	40-32	149	44-4	199
27-83	49	35-3	100	40-41	150	44-48	200
28-02	50						

No. 49.

TABLES SHOWING THE USUAL FORMS AND DIMENSIONS OF CASKS
IMPORTED INTO, AND USED IN THE UNITED KINGDOM.

Name and Description of Casks.	Usual Average Dimensions.					Usual allowance to reduce to a spheroid.
	Length.	Head.	Bung.	Content.	Thickness of Staves.	
WINE.						
Cape Pipes—stout made, various	47·8	22·8	28·5	96	1·0	·5 to 1·0
— Hogsheads—stout made	31·5	19·4	23·6	44	1·0	·2 to ·4
Claret, and Burgundy Hds—various	28·5	22·5	25·0	47	1·0 to 1·2	·0
Royal Pipes—various	47·5	21·7	27·7	89	various	·4 to ·6
Lisbon Pipes—bad fig. h. b. hollow q.	47·5	24·8	32·7	123	1·0	1·0 to 1·5
— Hogsheads—thin well made	29·0	25·0	28·0	60	·75	ad·3 to ·5
Madeira Pipes—rough, irr. stout, ill m.	47·5	21·4	28·5	93	various	1·0 to 2·0
— Hogsheads—stout, ill made	32·5	19·0	23·5	44	1·0	·3 to ·5
Mountain Butts—well made	41·0	26·6	32·0	106	1·0	·4 to ·6
Port Pipes—stout, well made	50·2	22·7	31·5	118	1·0	·3 to ·6
— Hogsheads—thin, well made	32·0	22·8	27·0	59	·75	·0
Rhenish Vats—good fig. dished heads	56·0	36·0	42·0	255	various	1·8 to 3·0
— Four Aums—smooth, well made	41·0	28·0	34·8	124	1·0	·6 to ·8
— Double Aums—smooth, good figures	31·5	23·7	27·5	61	1·0	·2 to ·4
Sherry Butts—thin, good figures	42·5	26·5	32·5	113	1·0	·2 to ·5
— Hogsheads—thin, well formed	30·5	23·0	26·5	55	·75	·0
Sicilian Pipes—stout made, various	46·4	22·4	28·6	93	1·0	·6 to 1·0
— Hogsheads—stout ill made	35·6	17·0	23·1	45	1·0	·4 to ·6
Spanish Red Pipes—cylindrical	47·2	25·6	28·8	103	1·0	·4 to ·7
Ditto—conical cocked bung	50·0	22·8	31·3	116	various	1·0 to 1·2
— Hogsheads—cylindrical rough made	30·0	21·0	24·0	45	1·0	·2 to ·4
Tenerife Pipes—thin, bad fig. hol. q.	47·4	23·3	28·8	98	1·0	·5 to ·7
— Hogsheads—long, thin made	32·0	19·0	24·5	47	·75	·2 to ·3
BRANDY.						
Bordeaux Pancheons—rough, ordinary	46·8	26·0	30·5	112	1·0	·4 to ·7
— Hogsheads—thick rough insides	37·5	25·5	28·5	80	1·0	·3 to ·5
Charante Pancheon—thin, good figure	46·0	26·5	31·0	114	various	·0 to ·4
Naples Pipes—bad figure, rough inside	46·0	26·5	31·5	116	1·0	·8 to 1·0
Spanish Butts—thick, rough, cylindric.	43·0	38·0	42·0	202	1·0	·7 to 1·0
— Pipes—ordinary	46·0	25·8	28·8	101	1·0	·4 to ·7
GENEVA.						
Pancheons—various	44·6	25·0	29·4	99	1·0	·3 to ·5
Hogsheads—various	33·0	19·5	25·5	52	various	·0
RUM.						
English Pancheon—good figure	34·5	27·6	32·3	92	1·0	·2 to ·4
West India Pancheon—bad figure					various	·3 to ·6
Hogsheads—long, thin bad figure					·75	·2 to ·4
Porter Casks—stout good figure	31·0	22·0	26·0	53	1·0	·2 to ·4
OLIVE OIL.						
Gallipoli Butts—short, ordinary	44·6	36·5	41·4	201	1·0	1·0 to 1·2
— Large Pipes—stout, ordinary	48·6	28·4	33·4	139	1·0	1·0
— Small Pipes—thin, ordinary	46·6	25·6	29·6	106	1·0	·6 to ·8
— Short Pancheons—thin, bad figure	35·6	29·2	32·6	100	1·0	·5
— Short Casks—thin, bad figure	29·6	24·6	28·6	62	1·0	·0
Genoa Butts—stout, ordinary figure	46·8	28·6	32·5	130	1·0	1·0
— Pipes—stout, well made	44·6	26·5	29·5	102	1·0	·6 to ·8
WHALE OIL.						
Large Butts—stout, well made	58·5	40·6	46·6	332	1·0	2·5
— Small Butts—do.	54·0	34·0	40·0	222	1·0	2·0 to 2·2
— Long Pipes—stout, well made	54·0	24·4	29·4	118	1·0	1·5 to 1·8
— Long Breakers—stout, well made	54·0	20·4	24·6	82	1·0	1·5 to 1·8

No. 80.

TABLE OF NET CISTERN AND COUCH BUSHELS.

	Gross Bushels.	Net Bus.	Gross Bushels.	Net Bus.	Gross Bushels.	Net Bus.	Gross Bushels.	Net Bus.	Gross Bushels.	Net Bus.	Gross Bushels.	Net Bus.	Gross Bushels.	Net Bus.
1	0615	42	34-23	92	74-96	142	115-73	192	156-46	242	197-23	292	237-98	
2	168	43	35-04	93	75-79	143	116-54	193	157-29	243	198-04	293	238-79	
3	244	44	35-86	94	76-61	144	117-36	194	158-11	244	198-86	294	239-61	
4	326	45	36-67	95	77-42	145	118-17	195	158-92	245	199-67	295	240-42	
5	407	46	37-49	96	78-24	146	118-99	196	159-74	246	200-49	296	241-24	
6	489	47	38-30	97	79-05	147	119-80	197	160-55	247	201-30	297	242-05	
7	570	48	39-12	98	79-87	148	120-62	198	161-37	248	202-12	298	242-87	
8	652	49	39-93	99	80-68	149	121-43	199	162-18	249	202-93	299	243-68	
9	733	50	40-75	100	81-50	150	122-25	200	163-00	250	203-75	300	244-50	
1	815	51	41-56	101	82-31	151	123-06	201	163-81	251	204-56	310	252-35	
2	163	52	42-38	102	83-13	152	123-88	202	164-63	252	205-38	320	260-80	
3	244	53	43-19	103	83-94	153	124-69	203	165-44	253	206-19	330	268-95	
4	326	54	44-01	104	84-76	154	125-51	204	166-26	254	207-01	340	277-10	
5	407	55	44-82	105	85-57	155	126-32	205	167-07	255	207-82	350	285-25	
6	489	56	45-64	106	86-39	156	127-14	206	167-89	256	208-64	360	293-40	
7	570	57	46-45	107	87-20	157	127-95	207	168-70	257	209-45	370	301-55	
8	652	58	47-27	108	88-02	158	128-77	208	169-52	258	210-27	380	309-70	
9	733	59	48-08	109	88-83	159	129-58	209	170-33	259	211-08	390	317-85	
10	815	60	48-90	110	89-65	160	130-40	210	171-15	260	211-90	400	326-00	
11	896	61	49-71	111	90-46	161	131-21	211	171-96	261	212-71	410	334-15	
12	978	62	50-53	112	91-28	162	132-03	212	172-78	262	213-53	420	342-30	
13	1059	63	51-34	113	92-09	163	132-84	213	173-59	263	214-34	430	350-45	
14	1141	64	52-16	114	92-91	164	133-66	214	174-41	264	215-16	440	358-60	
15	1222	65	52-97	115	93-72	165	134-47	215	175-22	265	215-97	450	366-75	
16	1304	66	53-79	116	94-54	166	135-29	216	176-04	266	216-79	460	374-90	
17	1385	67	54-60	117	95-35	167	136-10	217	176-85	267	217-60	470	383-05	
18	1467	68	55-42	118	96-17	168	136-92	218	177-67	268	218-42	480	391-20	
19	1548	69	56-23	119	96-98	169	137-73	219	178-48	269	219-23	490	399-35	
20	1630	70	57-05	120	97-80	170	138-55	220	179-30	270	220-05	500	407-50	
21	1711	71	57-86	121	98-61	171	139-36	221	180-11	271	220-86	510	415-65	
22	1793	72	58-68	122	99-43	172	140-18	222	180-93	272	221-68	520	423-80	
23	1874	73	59-49	123	100-24	173	140-99	223	181-74	273	222-49	530	431-95	
24	1956	74	60-31	124	101-06	174	141-81	224	182-56	274	223-31	540	440-10	
25	2037	75	61-12	125	101-87	175	142-62	225	183-37	275	224-12	550	448-25	
26	2119	76	61-94	126	102-69	176	143-44	226	184-19	276	224-94	560	456-40	
27	2200	77	62-75	127	103-50	177	144-25	227	185-00	277	225-75	570	464-55	
28	2282	78	63-57	128	104-32	178	145-07	228	185-82	278	226-57	580	472-70	
29	2363	79	64-38	129	105-13	179	145-88	229	186-63	279	227-38	590	480-85	
30	2445	80	65-20	130	105-95	180	146-70	230	187-45	280	228-20	600	489-00	
31	2526	81	66-01	131	106-76	181	147-51	231	188-26	281	229-01	610	497-15	
32	2608	82	66-83	132	107-58	182	148-33	232	189-08	282	229-83	620	505-30	
33	2689	83	67-64	133	108-39	183	149-14	233	189-89	283	230-64	630	513-45	
34	2771	84	68-46	134	109-21	184	149-96	234	190-71	284	231-46	640	521-60	
35	2852	85	69-27	135	110-02	185	150-77	235	191-52	285	232-27	650	529-75	
36	2934	86	70-09	136	110-84	186	151-59	236	192-34	286	233-09	660	537-90	
37	3015	87	70-90	137	111-65	187	152-40	237	193-15	287	233-90	700	570-50	
38	30-97	88	71-72	138	112-47	188	153-22	238	193-97	288	234-72	800	652-00	
39	31-78	89	72-53	139	113-28	189	154-03	239	194-78	289	235-53	900	738-50	
40	32-60	90	73-35	140	114-10	190	154-85	240	195-60	290	236-35	1000	815-00	
41	33-41	91	74-16	141	114-91	191	155-66	241	196-41	291	237-16			

No. 52.

TABLE OF MALT DUTY, AT 2s. 7d. PER BUSHEL, AND ALSO WITH 5 PER CENT. ADDITIONAL, INCLUDING THE CENTESIMAL PARTS OF A BUSHEL.

Bushe	At	Total	Bushe	At	Total	Bushe	At	Total	Bushe	At	Total
2s. 7d.			2s. 7d.			2s. 7d.			2s. 7d.		
s. d.	s. d.		s. d.	s. d.		£ s. d.	£ s. d.		£ s. d.	£ s. d.	
01	1	1	51	1 32	1 43	1	2 7	2 8	235	30 7 1	31 17 5
02	2	2	52	1 4	1 44	2	5 2	5 5	240	31 0 0	32 11 0
03	3	3	53	1 4 1	1 5	3	7 9	8 1 1	245	31 12 11	33 4 6
04	4	4	54	1 4 1	1 5 1	4	10 4	10 10	250	32 5 10	33 18 1
05	5	5	55	1 5 1	1 5 2	5	12 11	13 6 2	255	32 18 9	34 11 8
06	6	6	56	1 5 1	1 6	10	1 5 10	1 7 1 1	260	33 11 8	35 5 3
07	7	7	57	1 5 1	1 6 1	15	1 18 9	2 0 8 1	265	34 4 7	36 18 9
08	8	8	58	1 5 1	1 6 2	20	2 11 8	2 14 3	270	34 17 6	37 12 4
09	9	9	59	1 6 1	1 7	25	3 4 7	3 7 9 3	275	35 10 5	37 5 11
10	10	10	60	1 6 1	1 7 1	30	3 17 6	4 1 4 4	280	36 3 4	37 19 6
11	11	11	61	1 6 1	1 7 2	35	4 10 5	4 14 11 1	285	36 16 3	38 18 0
12	12	12	62	1 7 1	1 7 3	40	5 3 4	5 8 6	290	37 9 2	39 6 7
13	13	13	63	1 7 1	1 8	45	5 16 3	6 2 0 3	295	38 2 1	40 0 2
14	14	14	64	1 7 1	1 8 1	50	6 9 2	6 15 7 9	300	38 15 0	40 13 9
15	15	15	65	1 8 1	1 9	55	7 2 1	7 9 2 1	305	39 7 11	41 7 3
16	16	16	66	1 8 1	1 9 1	60	7 15 0	8 2 9	310	40 0 10	42 0 10
17	17	17	67	1 8 1	1 9 2	65	8 7 11	8 16 3 3	315	40 13 9	42 14 5
18	18	18	68	1 9 1	1 10	70	9 0 10	9 9 10 4	320	41 6 8	43 8 0
19	19	19	69	1 9 1	1 10 1	75	9 13 9	10 3 5 1	325	41 19 7	44 1 6
20	20	20	70	1 9 1	1 10 2	80	10 6 8	10 17 0	330	42 12 6	44 15 1
21	21	21	71	1 10 1	1 11	85	10 19 7	11 10 6 3	335	43 5 5	45 8 3
22	22	22	72	1 10 1	1 11 1	90	11 12 6	12 4 1 1	340	43 18 4	46 2 3
23	23	23	73	1 10 1	1 11 2	95	12 5 5	12 17 8 1	345	44 11 3	46 15 9
24	24	24	74	1 10 1	1 11 3	100	12 18 4	13 11 3	350	45 4 2	47 9 4
25	25	25	75	1 11 1	1 12	105	13 11 3	14 4 9 2	355	45 17 1	48 2 11
26	26	26	76	1 11 1	1 12 1	110	14 4 2	14 18 4 4	360	46 10 0	48 16 6
27	27	27	77	1 11 1	1 12 2	115	14 17 1	15 11 11 1	365	47 2 11	49 0 10
28	28	28	78	2 0 2	1	120	15 10 0	16 5 6	370	47 15 10	50 3 7
29	29	29	79	2 0 2	1 1	125	16 2 11	16 19 0 2	375	48 8 9	50 17 3
30	30	30	80	2 0 2	1 2	130	16 15 10	17 12 7 4	380	49 1 8	51 10 9
31	31	31	81	2 1 2	2	135	17 8 9	18 6 2 2	385	49 14 7	52 4 3
32	32	32	82	2 1 2	2 1	140	18 1 8	18 19 9	390	50 7 6	52 17 10
33	33	33	83	2 1 2	2 2	145	18 14 7	19 13 3 3	395	51 0 5	53 11 5
34	34	34	84	2 2 2	3	150	19 7 6	20 6 10 4	400	51 13 4	54 5 0
35	35	35	85	2 2 2	3 1	155	20 0 5	21 0 5 1	500	54 11 8	57 16 3
36	36	36	86	2 2 2	3 2	160	20 13 4	21 14 0	600	57 10 0	61 7 6
37	37	37	87	2 2 2	3 3	165	21 6 3	22 7 6 3	700	90 8 4	94 18 9
38	38	38	88	2 3 2	4	170	21 19 2	23 1 1 1	800	103 6 8	108 10 0
39	39	39	89	2 3 2	4 1	175	22 12 1	23 14 8 1	900	116 5 0	122 1 3
40	40	40	90	2 3 2	5	180	23 5 0	24 8 8	1000	129 3 4	135 12 6
41	41	41	91	2 4 2	5 1	185	23 17 11	25 1 9 3	2000	258 6 8	271 5 0
42	42	42	92	2 4 2	5 2	190	24 10 10	25 15 4 4	3000	387 10 0	406 17 6
43	43	43	93	2 4 2	6	195	25 3 9	26 8 11 1	4000	516 13 4	542 10 0
44	44	44	94	2 5 2	6 1	200	25 16 8	27 2 6	5000	645 16 8	678 2 6
45	45	45	95	2 5 2	6 2	205	26 9 7	27 16 0 3	6000	775 0 0	813 15 0
46	46	46	96	2 5 2	7	210	27 2 6	28 9 7 9	7000	904 3 4	949 7 6
47	47	47	97	2 6 2	7 1	215	27 15 5	29 3 2 1	8000	1033 6 8	1085 0 6
48	48	48	98	2 6 2	7 2	220	28 8 4	29 16 9	9000	1162 10 0	1220 12 6
49	49	49	99	2 6 2	8	225	29 1 3	30 10 3	10000	1291 13 4	1356 5 0
50	50	50	100	2 7 2	8 1	230	29 14 2	31 3 10 1			

No. 52.

TABLE OF SPIRIT DUTIES, AT 2s. 8d. IRISH, 8s. 8d. SCOTCH, AND 7s. 10d. ENGLISH;
INCLUDING THE CENTESIMAL PARTS OF A GALLON.

Gallon.	At 2s. 8d.	At 3s. 8d.	At 7s 10d	Gallon.	At 2s. 8d.	At 3s. 8d.	At 7s 10d	Gallons.	At 2s. 8d.	At 3s. 8d.	At 7s 10d.
s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	£ s. d.	£ s. d.	£ s. d.	
01	1	1	1	51	1	4	1	1	2	8	
02	1	1	1	52	1	4	1	2	5	4	
03	1	1	1	53	1	4	1	3	8	0	
04	1	1	1	54	1	5	1	4	10	8	
05	1	1	1	55	1	5	2	5	13	4	
06	1	1	1	56	1	5	2	6	16	0	
07	1	1	1	57	1	6	2	7	18	8	
08	1	1	1	58	1	6	2	8	1	9	
09	1	1	1	59	1	6	2	9	1	4	
10	1	1	1	60	1	7	2	10	1	6	
11	1	1	1	61	1	7	2	11	2	13	
12	1	1	1	62	1	7	2	12	4	0	
13	1	1	1	63	1	8	2	13	7	8	
14	1	1	1	64	1	8	2	14	9	6	
15	1	1	1	65	1	8	2	15	1	0	
16	1	1	1	66	1	9	2	16	3	8	
17	1	1	1	67	1	9	2	17	6	6	
18	1	1	1	68	1	9	2	18	8	4	
19	1	1	1	69	1	10	2	19	1	2	
20	1	1	1	70	1	10	2	20	4	0	
21	1	1	1	71	1	10	2	21	7	8	
22	1	1	1	72	1	11	2	22	9	6	
23	1	1	1	73	1	11	2	23	1	0	
24	1	1	1	74	1	11	2	24	4	8	
25	1	1	1	75	1	12	2	25	7	6	
26	1	1	1	76	1	12	2	26	9	4	
27	1	1	1	77	1	12	2	27	1	2	
28	1	1	1	78	1	13	2	28	4	0	
29	1	1	1	79	1	13	2	29	7	8	
30	1	1	1	80	1	14	2	30	9	6	
31	1	1	1	81	1	14	2	31	1	0	
32	1	1	1	82	1	15	2	32	4	8	
33	1	1	1	83	1	15	2	33	7	6	
34	1	1	1	84	1	15	2	34	9	4	
35	1	1	1	85	1	16	2	35	1	2	
36	1	1	1	86	1	16	2	36	4	0	
37	1	1	1	87	1	16	2	37	7	8	
38	1	1	1	88	1	17	2	38	9	6	
39	1	1	1	89	1	17	2	39	1	0	
40	1	1	1	90	1	18	2	40	4	8	
41	1	1	1	91	1	18	2	41	7	6	
42	1	1	1	92	1	18	2	42	9	4	
43	1	1	1	93	1	19	2	43	1	2	
44	1	1	1	94	1	19	2	44	4	0	
45	1	1	1	95	1	20	2	45	7	8	
46	1	1	1	96	1	20	2	46	9	6	
47	1	1	1	97	1	21	2	47	1	0	
48	1	1	1	98	1	21	2	48	4	8	
49	1	1	1	99	1	22	2	49	7	6	
50	1	1	1	100	1	22	2	50	9	4	

No. 53.

TABLE SHOWING THE DUTY ON PAPER, HARD SOAP, &c., AT 1½d. PER POUND;
AND ALSO WITH 5 PER CENT. ADDITIONAL.

lb.	1½d. per lb.	TOTAL.	lb.	1½d. per lb.	TOTAL.	lb.	1½d. per lb.	TOTAL.
	£ s. d.	£ s. d.		£ s. d.	£ s. d.		£ s. d.	£ s. d.
1	0 0 1½	0 0 1½	420	2 12 6	2 15 1½	920	5 15 0	6 0 9
2	0 0 3	0 0 3	430	2 13 9	2 16 5½	930	5 16 3	6 2 0½
3	0 0 4½	0 0 4½	440	2 15 0	2 17 9	940	5 17 6	6 3 4½
4	0 0 6	0 0 6	450	2 16 3	2 19 0½	950	5 18 9	6 5 0½
5	0 0 7½	0 0 7½	460	2 17 6	3 0 4½	960	6 0 0	6 6 0
6	0 0 9	0 0 9½	470	2 18 9	3 1 8½	970	6 1 3	6 7 3½
7	0 0 10½	0 0 11	480	3 0 0	3 3 0	980	6 2 6	6 8 7½
8	0 1 0	0 1 0½	490	3 1 3	3 4 3½	990	6 3 9	6 9 11½
9	0 1 1½	0 1 2	500	3 2 6	3 5 7½	1000	6 5 0	6 11 3
10	0 1 3	0 1 3½	510	3 3 9	3 6 11½	1010	6 6 3	6 12 6½
20	0 2 6	0 2 7½	520	3 5 0	3 8 8	1020	6 7 6	6 13 10½
30	0 3 9	0 3 11½	530	3 6 3	3 9 6½	1030	6 8 9	6 15 2½
40	0 5 0	0 5 3	540	3 7 6	3 10 10½	1040	6 10 0	6 16 6
50	0 6 3	0 6 6½	550	3 8 9	3 12 2½	1050	6 11 3	6 17 9½
60	0 7 6	0 7 10½	560	3 10 0	3 13 6	1060	6 12 6	6 19 1½
70	0 8 9	0 9 2½	570	3 11 3	3 14 9½	1070	6 13 9	7 0 5½
80	0 10 0	0 10 6	580	3 12 6	3 16 1½	1080	6 15 0	7 1 9
90	0 11 3	0 11 9½	590	3 13 9	3 17 5½	1090	6 16 3	7 3 0½
100	0 12 6	0 13 1½	600	3 15 0	3 18 9	1100	6 17 6	7 4 4½
110	0 13 9	0 14 5½	610	3 16 3	4 0 0½	1200	7 10 0	7 17 6
120	0 15 0	0 15 9	620	3 17 6	4 1 4½	1300	8 2 6	8 10 7½
130	0 16 3	0 17 0½	630	3 18 9	4 2 8½	1400	8 15 0	9 3 9
140	0 17 6	0 18 4½	640	4 0 0	4 4 0	1500	9 7 6	9 16 10½
150	0 18 9	0 19 8½	650	4 1 3	4 5 8½	1600	10 0 0	10 10 0
160	1 0 0	1 1 0	660	4 2 6	4 6 7½	1700	10 12 6	11 3 1½
170	1 1 3	1 2 3½	670	4 3 9	4 7 11½	1800	11 5 0	11 16 3
180	1 2 6	1 3 7½	680	4 5 0	4 9 8	1900	11 17 6	12 9 4½
190	1 3 9	1 4 11½	690	4 6 3	4 10 6½	2000	12 10 0	13 2 6
200	1 5 0	1 6 3	700	4 7 6	4 11 10½	2100	13 2 6	13 15 7½
210	1 6 3	1 7 6½	710	4 8 9	4 13 2½	2200	13 15 0	14 8 9
220	1 7 6	1 8 10½	720	4 10 0	4 14 6	2300	14 7 6	15 1 10½
230	1 8 9	1 10 2½	730	4 11 3	4 15 9½	2400	15 0 0	15 15 0
240	1 10 0	1 11 6	740	4 12 6	4 17 1½	2500	15 12 6	16 8 1½
250	1 11 3	1 12 9½	750	4 13 9	4 18 5½	2600	16 5 0	17 1 8½
260	1 12 6	1 14 1½	760	4 15 0	4 19 9	2700	16 17 6	17 14 4½
270	1 13 9	1 15 5½	770	4 16 3	5 1 0½	2800	17 10 0	18 7 6
280	1 15 0	1 16 9	780	4 17 6	5 2 4½	2900	18 2 6	19 0 7½
290	1 16 3	1 18 0½	790	4 18 9	5 3 8½	3000	18 15 0	19 13 9
300	1 17 6	1 19 4½	800	5 0 0	5 5 0	3100	19 7 6	20 6 10½
310	1 18 9	2 0 8½	810	5 1 3	5 6 8½	3200	20 0 0	21 0 0
320	2 0 0	2 2 0	820	5 2 6	5 7 7½	3300	20 12 6	21 13 1½
330	2 1 3	2 3 3½	830	5 3 9	5 8 11½	3400	21 5 0	22 6 3½
340	2 2 6	2 4 7½	840	5 5 0	5 10 3	3500	21 17 6	22 19 4½
350	2 3 9	2 5 11½	850	5 6 3	5 11 6½	3600	22 10 0	23 12 6
360	2 5 0	2 7 3	860	5 7 6	5 12 10½	3700	23 2 6	24 5 7½
370	2 6 3	2 8 6½	870	5 8 9	5 14 2½	3800	23 15 0	24 18 9
380	2 7 6	2 9 10½	880	5 10 0	5 15 6	3900	24 7 6	25 11 10½
390	2 8 9	2 11 2½	890	5 11 3	5 16 9½	4000	25 0 0	26 5 0
400	2 0	2 12 6	900	5 12 6	5 18 1½	5000	31 5 0	32 16 3
410	2 3	2 13 9½	910	5 13 9	5 19 5½			

No.	Under £10 per Annum.			Under £20 per Annum.			Under £25 per Annum.			Under £30 per Annum.			Under £40 per Annum.			Under £50 per Annum.			£50 or Upwards.		
1	2	4	1	4	8	2	6	12	8	7	14	4	8	16	4	9	18	5	11	0	6
2	4	8	2	8	16	4	13	4	7	15	8	8	17	12	9	19	16	10	22	1	0
3	6	12	8	13	4	6	19	16	10	23	8	0	26	9	24	28	16	33	38	1	6
4	8	16	4	17	12	9	26	9	2	30	17	4	36	5	7	39	18	9	44	2	0
5	11	0	5	22	0	11	38	9	1	38	11	8	48	4	1	49	12	25	56	2	6
6	13	4	6	26	9	1	46	6	0	46	6	0	52	14	4	59	10	7	68	3	0
7	15	8	7	30	17	3	53	13	0	54	0	0	61	18	4	64	19	0	77	8	0
8	17	13	8	35	5	12	58	18	2	61	14	0	70	14	9	73	7	6	88	4	0
9	19	16	9	39	13	8	64	50	10	7	39	9	79	7	6	79	6	11	96	4	0
10	22	0	10	44	1	10	66	2	1	77	7	8	88	3	11	99	4	10	110	5	0
11	24	4	11	48	10	0	72	15	24	84	17	8	97	16	4	109	2	9	121	5	6
12	26	9	0	52	18	3	79	7	6	92	12	0	105	16	9	119	1	3	132	6	0
13	28	18	1	57	6	5	85	19	0	100	6	4	114	13	13	128	19	8	143	6	6
14	30	17	2	61	14	7	92	12	1	108	0	8	123	9	6	138	18	1	154	7	0
15	33	1	3	66	2	9	99	4	4	115	15	0	132	5	11	148	16	6	165	7	6
16	35	5	4	70	11	0	106	16	8	123	9	0	141	2	4	158	15	0	176	8	0
17	37	9	5	74	19	9	112	8	11	131	8	149	15	8	163	15	5	187	8	6	
18	39	18	6	79	7	4	119	8	1	138	18	0	156	18	1	178	11	10	198	9	0
19	41	17	7	83	15	6	125	18	6	146	12	4	167	11	6	188	10	3	209	9	6
20	44	1	8	88	8	9	132	5	10	164	6	8	176	7	11	193	9	2	220	10	0

No. 55.

TABLE OF STAMP DUTIES.

55 G. 3, c. 184; 13 & 14 V. c. 97, &c.

BILLS AND PROMISSORY NOTES.				LEASES.	
£ s.	Not exceeding two months after date, or sixty days after sight, or on demand.	s. d.	For any longer period.		s. d.
2 0	and not above 5 5	1 10	1 6	Rent not above 5l.	0 6
5 5	" 20 0	1 6	2 0	Above 5l. and not above 10l.	1 0
20 0	" 80 0	2 0	2 6	10 "	15 "
30 0	" 50 0	2 6	3 6	15 "	20 "
50 0	" 100 0	3 6	4 6	20 "	25 "
100 0	" 200 0	4 6	5 0	25 "	50 "
200 0	" 300 0	5 0	6 0	50 "	75 "
300 0	" 500 0	6 0	8 6	75 "	100 "
500 0	" 1000 0	8 6	12 6	And where it shall exceed 100l., then for every 50l., and also for any fractional part of 50l.	
1000 0	" 2000 0	12 6	15 0		5 0
2000 0	" 3000 0	15 0	25 0		
3000 0 and upwards	...	25 0	30 0		
BONDS AND MORTGAGES.				LICENSES.	
Not exceeding 50l.	...	1s. 3d		Appraisers	£ s. d.
Above 50l. and not above 100l.	...	2 6		Attorneys, London	12 0 0
100 "	150 "	3 9		" elsewhere	8 0 0
150 "	200 "	5 0		Bankers	30 0 0
200 "	250 "	6 3		Conveyancers, London	12 0 0
250 "	300 "	7 6		" elsewhere	8 0 0
And where the same shall exceed 300l., then for every 100l., and also for any fractional part of 100l.	...	2 6		Hawkers and pedlars, on foot	4 0 0
CONVEYANCES.				" and for each horse, &c., used	4 0 0
Purchase, not exceeding 25l.	...	0 2 6		" in Ireland, on foot	2 2 0
Above 25l. and not above 50	...	0 5 0		" ditto for each horse used	2 2 0
50 "	75 "	0 7 6		Makers of playing cards or dice	0 5 0
75 "	100 "	0 10 0		Medicine vendors, London	2 0 0
100 "	125 "	0 12 6		" and other corporate towns	0 10 0
125 "	150 "	0 15 0		" elsewhere	0 5 0
150 "	175 "	0 17 6		Pawnbrokers, London	15 0 0
175 "	200 "	1 0 0		" elsewhere	7 10 0
200 "	225 "	1 2 6		Plate dealers, from 2l. 6s. to	5 15 0
225 "	250 "	1 5 0		For marriages, special	5 0 0
250 "	275 "	1 7 6		" not special	0 10 0
275 "	300 "	1 10 0		To hold a perpetual curacy	3 10 0
300 "	350 "	1 15 0		Stage carriage drivers, &c.	0 5 0
350 "	400 "	2 0 0		RECEIPTS.	
400 "	450 "	2 5 0		For 5l. and under 10l.	s. d.
450 "	500 "	2 10 0		10 "	20 "
500 "	550 "	2 15 0		20 "	50 "
550 "	600 "	3 0 0		50 "	100 "
And where the purchase shall exceed 600l., then for every 100l., and also for any fractional part of 100l.	...	0 10 0		100 "	200 "
				200 "	300 "
				300 "	500 "
				500 "	1000 "
				1000 and upwards	10 0
				In full of all demands	10 0
				WARRANT OF ATTORNEY.	
				Same as Bond.	

For the other Stamp Duties see *Tisley's Stamp Laws*.

No. 56.

TABLE OF ASSESSED TAXES AND INCOME TAX.

48 Geo. 3 c. 55; 5 & 6 Vic. c. 35; 14 & 15 Vic. c. 56, &c.

ARMORIAL BEARINGS.										
Having a Coach or Carriage . . .	£	s.	d.	Every other Person	£	s.	d.			
No Carriage, but chargeable to House Tax	2	8	0		3	13	6			
Other Persons	1	4	0	HAIR POWDER.						
	0	12	0		£	s.	d.			
				Persons wearing or using . . .	1	3	6			
CARRIAGES.				HORSES.						
Carriages with four wheels:—				Horses for Riding or Drawing						
No. Per Carriage.	No. Per Carriage.			Carriages:—						
£ s. d.	£ s. d.			No. Each Horse.	No. Each Horse.					
1 6 0 0	6 8 4 0			£ s. d.	£ s. d.					
2 6 10 0	7 8 10 0			1 1 8 9	9 3 0 9					
3 7 0 0	8 8 16 0			2 2 7 8	10 to 12 3 3 6					
4 7 10 0	9 9 1 6			3 2 12 3	13 to 16 3 3 9					
5 7 17 6				4 2 15 0	17 3 4 0					
For every additional Body . . .	3 3 0			5 2 15 9	18 3 4 6					
Carriages let by Coachmakers without horses, each	6 0 0			6 2 18 0	19 3 5 0					
Carriages let with two or more horses, except those specified below	6 0 0			7 or 8 2 19 9	20 3 6 0					
Post Chaises	3 0 0			Horses let without Post Duty						
One-horse Carriages	4 10 0				1 8 9					
Unless kept solely for being let by the mile, and marked as required, then	3 0 0			Race Horses, each	3 10 0					
Carriages with wheels of less than 30 inches, drawn by ponies or mules exceeding 12 hands, and not 13 in height. <i>Exemption.</i> —Carriages with wheels of less than 30 inches, drawn by ponies or mules not exceeding 12 hands.	3 5 0			Butchers' Horses	1 8 9					
Carriages with less than 4 wheels, except those next mentioned	3 5 0			If two only, the 2nd at	0 10 6					
If kept solely for being let by the mile, and duly marked	3 0 0			Horses for Riding, not above 13 hands, each	1 1 0					
Carriages drawn by 2 or more horses or mules	4 10 0			Other Horses, used in trade, and mules, each	0 10 6					
For every additional Body . . .	1 11 6			Horse Dealers' Duty, London	25 0 0					
<i>Exemption.</i> —Carriage whose value never exceeded 21 <i>l.</i> and marked with name, &c.				Elsewhere	12 10 0					
DOGS.				HOUSES.						
	£	s.	d.	For every inhabited House						
For every Greyhound	1	0	0	worth 20 <i>l.</i> per annum or upwards, if used as a shop or farmhouse, for every 20 <i>s.</i> of the value						
For every Hound, Pointer, &c., where two are kept	0	14	0	When not so used						
" where one is kept	0	8	0	INCOME TAX.						
Composition for Hounds	36	0	0	For every 20 <i>s.</i> annual income						
				or property						
GAME.				<i>Exemption.</i> —When the total income is less than 150 <i>l.</i>						
Game Keeper, assessed as a servant	£	s.	d.	MALE SERVANTS.						
" not so assessed	1	5	0	No. Per Servant.	No. Per Servant.					
	3	13	6	£ s. d.	£ s. d.					
				1 1 4 0	7 2 12 6					
				2 1 11 0	8 2 16 0					
				3 1 18 0	9 3 1 0					
				4 2 3 6	10 3 6 6					
				5 2 9 0	11 3 16 6					
				6 2 11 6						
				All above 11 at the rates last mentioned. Bachelors' servants are charged 1 <i>l.</i> each extra.						
				Waiters in Taverns, each						
				Coachmen, &c., let on job						
				[By 3 V., c. 17, 10 per cent. additional is payable on assessed taxes, except certain carriages.]						

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